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FOOD AND THE
PRINCIPLES OF DIETETICS

Extract from "Greek Byways," by T. R. Glover

The day will yet come, when the progress of research through long ages will reveal to sight the mysteries of nature that now are concealed. A single lifetime, though it were wholly devoted to the study of the sky, does not suffice for the investigation of problems of such complexity. It must take long successive ages to unfold all. The day will yet come when our descendants will be amazed that we remained ignorant of things that will to them seem so plain. Veniet tempus quo posteri nostri tam aperta nos nescisse mirentur.

SENECA. *Nat. Quaest.* VII, 25, 2.

HUTCHISON'S

FOOD AND THE PRINCIPLES OF DIETETICS

REVISED BY

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TENTH EDITION

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PREFACE TO THE TENTH EDITION

Although some measure of peace will have been attained by the time this edition appears, its preparation was so overshadowed by war and the aftermath of war that the picture which we present cannot have the balance and perspective we should wish. Almost the whole of Part I, Diet in Normal Life, is new, for the energy problem had to be restated in view of the extreme variability of the individual; the minimal protein intake to be reviewed in the light of evidence from the experimental use of isotopes; work upon the factors influencing calcium uptake and the effect of trace elements included and the section on vitamins thoroughly revised and especial reference made to the " refection " of the B group and the practical applications of that knowledge. Two new brief chapters on the processing and hygiene of food have been incorporated into this part.

Part II, The Nature of Foods, has been further compressed and also rearranged to give a somewhat more logical order of treatment. Part III, The Principles of Feeding in Infancy and Childhood, for which Dr. C. F. Harris is responsible, has been almost entirely rewritten. Part IV, Diet in Treatment of Disease, has been much modified and expanded. For example, the sections on obesity, diseases of the liver, rickets and scurvy have been revised and largely rewritten. The fallacies and dangers of the Hay diet have been fully set out and a new section on phosphaturia included. The various solutions for intravenous feeding have been described, including the new treatment with amino-acids. The list of proprietary preparations of vitamins has again been revised.

We very much regret that, despite compression, the book runs to 70 extra pages, but the science of nutrition has grown, is growing and should be encouraged to grow. We have had to make a compromise between a minimal diet and a plethora. We hope that our choice may commend itself.

Acknowledgments are due to Mr. A. L. Bacharach, Miss M. W. Grant, Dr. McCance and Miss Widdowson for suggestions and help, to the Librarian and library staff of the Royal Society of Medicine for their patience in hunting references, and to Mrs. V. H. Mottram for proof-reading.

V. H. M.
G. G.

PREFACE TO THE NINTH EDITION

This book first appeared in the last year of the nineteenth century, since when it has gone through edition after edition and for forty years has held the field as the one major work on dietetics published in Great Britain. It is a lasting monument to the foresight and genius of its first author, Sir Robert Hutchison, for when it first appeared it is fair to say that few even among the medical profession had perceived the importance of the scientific study of nutrition in the feeding of the people and the treatment of disease. Now all that has changed. Not only have we in this country become "dietetics conscious" under the stimulus of two great wars and the example of that great Nation across the Atlantic, but our statesmen and politicians are compelled to think and act in terms of calories, proteins and vitamins. To that change of outlook and action there is no doubt that Sir Robert's book has largely contributed, and it has been well for us that a work of such balanc and sanity expressed in lucid and graceful language was there t check and control the exuberance and flamboyance of the neophyte in that new study, dietetics.

As was said above, this work appeared in 1900, when we, the present editors, were in our academic swaddling clothes. Our diffidence may easily be pictured when we were asked to undertake the editing of this, the ninth edition. It is true that one of us had been associated with two earlier editions, but now the revised version was to be wholly in our hands. The problem was: were we to produce a modern translation of the original text, or were we to subject it to a radical reconstruction?

Two considerations influenced us in our decision. There is no longer a need for an encyclopædic book upon dietetics, for many parts of the new subject now have their own expositors. Authoritative tables, for instance, of analyses and calorie values of foods have appeared and will be in the hands of every sane student of dietetics. Compilations of the vitamin values of the various foods in our diet have been made, are being made, and are easily available to all. Consequently we felt that the new edition should take on more the nature of a textbook and less that of an encyclopædia, though we hope, as Sir Robert hoped with reason and justification in the preface to the first edition, that the book may "prove intelligible and interesting to anyone desiring to acquire some knowledge of foods and the difficult problems of nutrition."

In the second place we felt that the development of the subject since the last war has so altered the relative proportions and importance of its constituent parts that the book needed much rearrangement and rewriting. We have left Sir Robert's delightful introduction, The History of Dietetics, entirely as it stood in the eighth edition, but from that point onwards the hand of the reviser has been heavy. All the chapters on the proximal principles of food and on dietetics, with chapters on the cooking, digestion and metabolism of foods and the practical applications to normal dietetics of the matters discussed, have been brought together to form a coherent whole. All these (the first eight chapters, pp. 1–203) have been rewritten, though we have gladly availed ourselves of a felicitous phrase or apt illustration due to the book's first author. The chapters on the nature of foods (Chapters IX to XXV, pp. 205–462) have not received so radical a reconstruction, though they have been considerably revised and compressed, and brought up to date. The final chapters of the book (Chapters XXVI to XXXII, pp. 463–630), which deal with the principles of dietetics in feeding in infancy and childhood and with feeding in disease, have been almost entirely rewritten. Dr. C. F. Harris has taken in charge the chapters on feeding in infancy and childhood, and our best thanks are due to him.

Many of the analyses of proprietary foods quoted in this book are pre-war analyses. We realize that the composition of these may have changed owing to war-time restrictions in the use of materials (e.g. milk proteins). It has been impossible to check these alterations and the original figures have been quoted to show what the foods originally contained and what it may be hoped they will contain when raw materials again become available.

We realize only too well that there must be faults and lacunæ in our handling of the subject, for the authors of a perfect textbook on dietetics must not only be competent as physician, physiologist and biochemist, but should have more than a passable competence as cook, biologist, psychologist, *bon viveur* and, above all, as literary artist. We hope for indulgence for falling short of this standard.

And particularly we hope for indulgence in that this revision of the book has been made in the paralysing circumstances of war when both of us were evacuated, or better "dispersed," from our usual haunts; this making the use of libraries, the verifying of references and the mutual consultation necessary in collaboration almost an impossibility, not to speak of the vexatious delays in working conditions in war-time. Though war has twice proved an incentive to the study of dietetics it is none the less true that that study needs quiet for its promotion and practice. If our work shall have done anything to contribute to the reconstruction of the health and well-being of this country when victory and peace are happily attained we shall feel abundantly rewarded.

V. H. M.
G. G.

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In a book on dietetics it is difficult to avoid the use of several different standards of measurement. Thus, the Metric System is usually employed in the scientific analyses of foods, and the Imperial System in the measurement of foodstuffs as purchased in this country, whilst even such rough domestic standards as spoons and cups must sometimes be referred to. The following table of equivalents of the different standards may therefore be found of use :

1 gramme = 15·4 grains.
1 kilogramme = 2 pounds 3¼ ounces.
100 grammes = 3½ ounces (approx.).

1 ounce = 28·3 grammes.
1 pound = 453·5 ,,
1 fluid ounce = 28·4 c.c.
1 pint = 568 ,,

1 pint = 20 fluid ounces.
1 tumblerful = 5–6 ,, ,,
1 breakfastcupful = 8 ,, ,,
1 teacupful = 4 ,, ,, (approx.).
1 claret-glassful = 4 ,, ,,
1 sherry-glassful = 2 ,, ,,
1 tablespoonful = one-half fluid ounce.

INTRODUCTION

THE HISTORY OF DIETETICS[1]

Dietetics is really a very young branch of science; it was not indeed, until the middle of the last century that it could fairly be described as a science at all. This, it need hardly be said, was inevitable, for diet could not be studied satisfactorily until organic chemistry and the physiology of nutrition had made considerable advances. Even down to the beginning of last century the very word "diet" was not always used in its modern acceptation, but still generally included a consideration of all of what used to be termed the "non-naturals" (air, aliment, exercise and rest, the passions and affections of the mind, wakefulness and sleep, repletion and evacuation). Thus Willich, writing as late as the year 1800, defined dietetics as "a systematic view of all objects relative to health in general and to food and drink in particular"; it embodied, in short, everything that was known as to physical and mental hygiene and the promotion of individual health. This use of the term must always be borne in mind when studying the earlier history of the subject.

It was natural, of course, that some attention should have been given to the feeding of the sick so soon as anything like a systematic study of disease had begun, and we find indications of this in the Scriptures and, as far as the Egyptians were concerned, in the writings of Herodotus, while Pythagoras, the founder of vegetarianism, flourished as long ago as the sixth century B.C. It was with the dawn of Greek medicine, however, that the first faint beginnings of dietetics, as we now understand the term, may be discerned; but in no sense could Greek dietetics be described as scientific. It was not based even upon the result of observation, but was distorted by a false pathology and by unintelligible and semi-metaphysical hypotheses. We can see this if we glance at the writings of Hippocrates, Celsus, and Galen—the three great Masters of Ancient Medicine. Hippocrates (460–377 B.C.), in his *Treatise on Ancient*

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[1] An article first published by Sir Robert Hutchison in *The Practitioner*, January, 1934, and reproduced here by permission of the Editor of that Journal.

Medicine, says that men first learned from experience the science of dietetics; they were compelled to ascertain the properties of vegetable products as articles of food. Then they learned that the food which is suitable in health is unsuitable in sickness, and thus they applied themselves to the discovery of the proper rules of diet in disease; and it was the accumulation of the facts bearing on this subject which was the origin of the art of medicine. This may be true enough; but on turning to his practical dietetics as expounded in his books *On Regimen in Acute Diseases* and *On Nutriment* we find how empirical he was and how far from any scientific conception of the subject. He insisted that the diet should be full in winter and spare in summer. He disapproved of the habit of eating a full dinner, and condemned the use of new bread. The nutritious properties of pulse in general were insisted upon. He called the flesh of fowls one of the lightest kinds of food and stated that eggs are nutritious and strengthening, but flatulent. He remarked that the flesh of wild animals is more digestible than that of domesticated. He objected to goat's flesh as having all the bad qualities of beef, which he called a strong, astringent, and indigestible article of diet. Milk, he said, sometimes causes the formation of stones in the bladder. Cheese he considered flatulent and indigestible. Fishes were light food; sea fish lighter and better for delicate persons than fresh-water fish. Honey, when eaten with other food, was nutritious, but injurious when taken alone. He discussed also in great detail the use of barley gruel in acute diseases.

Celsus (53 B.C.–A.D. 7), who flourished about the time of Augustus and Tiberius, in the preface to his great work *De Re Medica* (in eight books),[1] states that in dietetics there are two schools—the Rationalists, who proceed on theory and principle, and the Empirics, who rely upon experience. Celsus belonged to the former. In his first book generalities are considered, in the second he discusses the nature of foods and divides them according to their "materia" into (1) the strongest, (2) the medium, (3) the weakest; the strongest have most nutriment. He was rather arbitrary in placing foods in each class; for example, he thought that large animals were more nourishing than small, and birds which use their feet "stronger" than those that fly, but in the main his allocation is sound enough. The more powerful the "materia" the less easily was it digested, but, being digested, the more it nourished. Further, some foods were of "good juice" and some of bad; some were palatable, some acrid, some made the more crass Pituita in us, some the thinner kind; some were flatulent, others not; some heated, others chilled; some turned sour; some were diuretic, others had the contrary effect, and so on. He gave examples of foods of each quality. In the third book he describes the dietary of diseases; in fevers, for instance, the diet should be strong, simple, dry, frigid, e.g. toasted bread, roast meat, dry wines. In apoplexy game was the best food and warm water the best drink. In ulcerated stomach he recommended light and viscous foods—none that is acid. He did not give any "scientific" reasons for his diet in disease or any principles, but his practice is not so much amiss.

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[1] RIDDELL, W. R. (1931), "The Dietetics of Celsus," *Med. Journ. and Record*, 134, 247.

Galen (A.D. 130–200) wrote three books on the *Faculties or Powers of Aliments.* In Book I he says that many ancient writers had treated of the power of aliment but differed so greatly amongst themselves that a new work was required "founded on reason and experience." He gives an account of numerous foods—e.g. wheat and the articles prepared from it; barley; oats and other cereals; beans and vetches, etc. In the second book, which has 71 chapters, he deals with fruits and vegetables. In the third book he discusses animal foods. He also wrote a work on "the good or bad juices of Food," a kind of commentary on every variety of aliment. He recommended the use of human milk in phthisis and had a good deal to say about wines. On the whole, the writings of Galen are decidedly more modern than those of his predecessors.

The Arabian physicians added little to the knowledge of dietetics which they took over implicitly from the Greeks. They were more concerned with the prescription of drugs, though Rhazes (850–923), the "Galen of the Arabs," provided the excellent maxim: "When you can heal by diet prescribe no other remedy."

To the Arabians succeeded the mediæval school, and we can get some idea of mediæval dietetics from the *Isagoge* of Joannitius (809–873), which was a textbook of medicine throughout the Middle Ages.[1] Speaking of foods he says: "Foods are of two kinds. Good food is that which brings about a good humour, and bad food is that which brings about an evil humour. And that which produces a good humour is that which generates good blood; namely, that which is in the mean state as regards quality and working. Such is clean, fresh, fermented bread, and the flesh of lamb or kid. Bad food brings about the contrary state, and such is old and bran bread, or the flesh of old beeves or goats. Foods producing good or evil humours may also be heavy or light. Of the first kind are pork and beef, of the second chicken or fish. And of these the flesh of the middle sized and more active kinds is better than that of the fatter and scaly varieties. Certain kinds of vegetables produce evil humours; for instance, nasturtium, mustard and garlic beget reddish bile. Lentils, cabbage, and the meat of old goats or beeves produce black bile. Pork, lamb, purslain, and attriplex beget phlegm. Heavy foods produce phlegm and black bile, and either of these is evil." We can here see the distorting influence of the humoral doctrines in full operation.

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[1] CHOLMELEY, H. P. (1912), *John of Gaddesden*, Oxford, The Clarendon Press, 145.

Perhaps the best known, however, of mediæval writings is the *Regimen Sanitatis*, produced at the famous school of Salerno about the year 1100. It was a popular treatise on health in general, written in rhyme. We may quote two verses dealing with diet:[1]

> Doctors should thus their patients food revise—
> *What* is it? *When* the meal? and what its *size?*
> How *often?* *Where?* lest, by some sad mistake,
> Ill-sorted things should meet and trouble make.
>
> We hold that men on no account should vary
> Their daily diet until necessary:
> For, as Hippocrates doth truly show,
> Diseases sad from all such changes flow.
> A stated diet, as it is well known,
> Of physic is the strongest cornerstone—
> By means of which, if you can nought impart,
> Relief or cure, vain is your Healing Art.

The *Rosa Anglica*, written by John of Gaddesden (?1280–1361) about the year 1314, was intended for medical readers in the first instance, but was apparently largely borrowed from the *Regimen Sanitatis*. It gives a good idea of fourteenth-century medicine but shows little advance on the views of Hippocrates. Here is a sample of his dietetic teaching: "Some eat more of fruit than of other food, wherein they do not well, for all fruits make watery useless blood, and prone to putrefaction—— On the whole it is best to do without fruit altogether."

Andrew Boorde (1490?–1549) wrote his well-known book, *A Compendyous Regyment, or A Dyetary of Helth*, about 1542, a century after the close of the Dark Ages. It is a popular work and deals with the general management of health, but has many chapters on the different classes of foods, and others on the diet for different kinds of diseases. His statements about foods are often rather arbitrary and, of course, coloured by the prevailing humoral pathology of his day. Here are some extracts: "Bread having too much bran in it is not laudable." "Barley doth breed cold humours." "Butter is made of crayme and is moyste of operation." "Al maner of fysshe is cold of nature and doth ingender fleume." "Hare's flesh is dry and doth ingender melancholy humors." "Peason and beanes repletyth a man with Ventosyte." "Milk is not good for them the which have gurgulacyons in the bely."

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[1] Walsh, J. J. (1920), *Medieval Medicine*, London, 53.

About a century after Boorde's *Dyetary of Helth* two notable books on the subject were published in this country:[1] *Κλινικὴ or the Diet of the Diseased*, by Dr. James Hart of Northampton, appeared in 1633, and the other, *Via Recta ad Vitam longam*, by Dr. Tobias Venner (1577–1660) of Bath, was first published in 1620, the last edition appearing in 1660. The latter is perhaps the better known, though Hart's is really the more interesting and important, but both writers use the word diet to cover general rules of health. *Κλινικὴ* is a handsome folio and is written in a delightful style recalling often that of Burton's *Anatomy of Melancholy* which had appeared a decade earlier. It contains short descriptions of the foods then in use and of their qualities, but is largely compiled from the writings of Galen, Dioscorides, and other classical authorities. This passage is characteristic:

> "Marjoram is a sweet, pleasant and well-smelling herb, hot and dry in operation . . . It comforteth all the noble parts, especially the stomacke, and may with good success be used to further concoction, comfort the stomacke and discusse wind. It much comforteth the braine also and is good against all cold diseases of the braine and nervous parts."

There are some satirical touches as when, in speaking of potatoes (then recently introduced into England), the writer says: "That outlandish root brought with us from the West Indies, called commonly Potato, and by some Batato, is of the same nature and property as the Skirret root or at least goeth a little beyond it but this pre-eminence it hath that it is, according to the common proverb, 'Farre fetcht and deare bought and therefore good for Ladies.'" There is also a chapter, unique perhaps in the literature of the subject, entitled "Of strange and uncoth [sic] Diet, which some people have in ordinarie use; as of Dogges, Cats, Horses, Mules, Asses, Rats, Locusts, Frogges, Snailes and Man flesh."

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[1] Mention should also be made of a book by Thomas Moffet (? 1540–1604) entitled *Health's Improvement: or Rules Comprizing and discovering the Nature, Method and Manner of Preparing all Sorts of Food Used in this Nation*, which must have been written towards the end of the sixteenth century although it was not published until 1655, fifty years after the author's death. A revised edition with an Introduction by Dr. Robert James and a biographical account of Dr. Moffet appeared in 1746. *Health's Improvement* is much on the same lines as the books of Hart and Tobias Venner and contains a general classification and description of foods and their properties as then understood.

The *Via Recta*, neither so elaborate nor so well written as *Κλινική*, had greater popularity. The first part deals with the "Nature and choice of Habitable places" and then there follows an interesting section on "Bread," in which the great brown bread controversy is already foreshadowed. In a chapter on the "Divers kinds of Drinks," the author speaks eloquently in praise of wine:

> "Many and singular are the commodities of Wine: for it is of it selfe, the most pleasant liquor of all other, and was made from the beginning to exhilarate the heart of man. It is a great increaser of the vitall spirits, and a wonderfull restorer of all concoction, distribution, and nutrition, mightily strengtheneth the naturall heat, openeth obstructions, discusseth windinesse, taketh away sadnesse, and other hurts of melancholy, induceth boldnesse and pleasant behaviour, sharpeneth the wit, abundantly reviveth feeble spirits, excellently amendeth the coldnesse of old age, and correcteth the tetrick qualities which that age is subject unto; and to speak all in a word, it maketh a man more coragious and lively both in mind and body."

He adds the comfortable advice that wine should be given "with a liberall hand to men in the later part of old age—from sixty yeeres upward." He discusses also "whether it would be expedient for health to be drunk with wine once or twice a month" and concludes not, but thought it good for those who are "wearied with great cares and labours" to drink sometimes "until they be merry and pleasant but not drunken." He next considers foods in detail. A few examples will show the nature of his teaching and how full it is of dogmatic statements and how entirely based, like that of his predecessors, upon the humoral doctrines:

> "Bisket-bread is only profitable for the phlegmatick and them that have crude and moist stomacks, and that desire to grow lean because it is a great drier; and therefore let such as are cholerick and melancholick beware how they use it."
>
> "Eels are very hurtful to those with gout, dropsy or stone."
>
> "Lampreys increase melancholy and are hurtfull to those with weak sinews."
>
> "Mullet breedeth grosse and excrementall humors."
>
> "Beanes are cold and hot in the first degree."
>
> "Chestnuts are hot in the first degree and dry in the second."

The chapter "Of the Manner and Customs of Diet" contains, however, much sound general advice, e.g.:

> "The dining-room must not be 'bloomy' hot; for that may

soone occasion faintness and swouning by weakning the naturall heat and extracting the spirits."

"To feed upon more than foure dishes even at a geniall meale, is somewhat immodest and excessive."

Three things, he thought, were necessary at meals, an easy mind, thorough chewing and "not to reside in the chair of intemperance."

After the *Via Recta* no important book on dietetics appeared in this country for another hundred years, when Dr. John Arbuthnot, the well-known physician of Queen Anne's reign, published his essay "Concerning the Nature of Aliments and the Choice of them" in 1732. It is a popular work, for he remarks in his preface, "I do not presume to instruct the Gentlemen of my own Profession," and it is written in the form of a number of dogmatic propositions, for example:

"Honey is the most elaborate Production of the Vegetable kind, being a most exquisite soap, resolvent of the Bile, Balsamick and Pectoral."

"Acrimony and tenacity are the two qualities in what we take inwardly most to be avoided."

"The constituent parts of animals are (1) earth, (2) a peculiar spirit analogous to that of plants, (3) water, (4) salts, (5) oil."

"The fruits of most vegetables are soaps; all soaps (which are a mixture of salt and oil) are attenuating and deobstruent, resolving viscid substances."

In a later edition he said that part of his treatise had been censured as obscure and unpractical—as well it might be—and indeed the whole book shows little advance upon Andrew Boorde, or, for the matter of that, upon Hippocrates. The contributions of the eighteenth century to the science of dietetics were, indeed, negligible, notwithstanding the fact that it was in this century that the curative effect of fruit and green vegetables in scurvy was first clearly recognized; but that came about through the practical observations of the great voyagers such as Captain Cook, and not through the labours of scientists. Grateful mention must be made, however, of the work of William Stark (1740–70), who was one of the first experimental dietitians in this country, although his well-meant experiments conducted upon himself tended probably to shorten his life (he died at the age of 29) rather than to add to knowledge.

How little dietetics had even been influenced by the advance of chemistry, especially in France, throughout the century, is shown by Willich's *Lectures on Diet and Regimen* (1800), for he describes fat as "the cellular substance of animal jelly" and salt as "an excellent solvent of fat." Nor had he entirely shaken off the humoral doctrines, for he describes apples as "serviceable in diseases of the breast; to remove spasmodic contractions, to neutralize acrimony and to attenuate viscid phelgm," and says of veal that it "contains many nourishing and earthy particles, and is the most proper food for persons who have a disposition to hæmorrhage." On account of the great proportion of "viscidity" it contains, persons disposed to "phlegm" and complaints of the abdomen ought to refrain from it. He considered that it would be beneficial to Society if the making of butter was prohibited. Dripping was equally bad and should only be used "for greasing cart wheels." On the other hand he anticipated modern teaching in recommending two-thirds of vegetable to one-third of animal food as the best proportion in the diet.

By the time of the first publication of Forsyth's *Dictionary of Diet* (2nd edition 1834) the influence of chemistry had begun to make itself felt, though uncertainly, and he speaks of alcohol as "inferred to consist of two atoms of carbon, one of oxygen, and three of hydrogen," and honey as "supposed to consist of sugar, mucilage and an acid."

Paris's *Treatise of Diet* (5th edition 1837), however, showed a real advance and is almost the first book dealing with the subject on modern lines. His classification of the nutrientia into fibrinous, e.g. flesh; albuminous, e.g. eggs; farinaceous, e.g. wheat, and so forth, is a great improvement upon his predecessors, of whom he justly says in his introduction: "Were the popular works on dietetics subjected to a healthy digestion, how meagre would be the proportion of real aliment extracted from their bulky materials." He has incidentally much interesting information on the history of foods; thus he tells us that cabbages were not cultivated in England until the time of Catherine of Aragon and that "this queen could not procure a salad till a gardener was sent for from the Netherlands to raise it"; and that carrots were introduced by the Flemings in the reign of Elizabeth and turnips by Lord Townshend, Secretary to Charles I.

Jonathan Pereira, who was Assistant Physician to the London Hospital, brought out in 1843 a *Treatise on Food and Diet*, in the preface to which he states that his book "contains an account of the chemical elements of food—a subject which previous writers had almost altogether passed over but to which the recent researches of Boussingault, Liebig, and Dumas have given additional interest." He speaks of foods as "compound aliments" and classifies the "alimentary principles" composing them as "the aqueous, the mucilaginous, the saccharine, the amylaceous" and so on. He gives a general description of the different foods with the time required for their digestion (largely based on Beaumont's observations on Alexis St. Martin) and full analyses of most of them, sometimes in terms of carbon and nitrogen, sometimes in those of "alimentary principles." His figures for the composition of milk, for example, are, casein 4·2 per cent., butter 3 per cent., sugar of milk 5·3 per cent., and salt 0·75 per cent., which is not so far wrong. He also recognized that alcohol is a fuel in the body and he speaks for the first time of "proteine" which had recently been discovered by Mulder.

The advance of chemistry had therefore already begun to affect dietetics, but by the middle of the century great progress was also being made in the physiology of nutrition, as the result chiefly of the labours of the German school; and by the seventies the relative values of the different nutritive constituents of food and their equivalents in heat and work had been made out, and the proof of the conservation of energy in the body was on the way to being established. The effect of this work on dietetics was immediate and it is from this time that it can fairly claim to be regarded as an exact science. The changed aspect of the subject is reflected in three books which appeared in the 7th decade of the century—Letheby's *Cantor Lectures on Food* (1870), Edward Smith's *Foods* (1873), and, most of all, in Pavy's *Treatise on Food and Dietetics* (1874). Full analyses of foods are given in all of these, though there is still sometimes noticeable a tendency, traceable to Liebig, to express the results in terms of nitrogen and carbon instead of in those of protein, carbohydrate and fat. The dynamic and heat values of different foods are stated and Liebig's heresy that protein is the source of work, which had been contradicted by Traube ten years earlier (1861), is now finally discarded. Pavy's book, indeed, is entirely modern in its treatment of the subject, and very little was added to what it contains throughout the following 25 years. During that period, it is true, the metabolism of food was further worked out chiefly by Carl Voit and Rubner in Germany, and by Atwater, Lusk and others in America, but in the main it may be said that the quantitative aspect of dietetics was exhausted by the end of the nineteenth century. By that time the importance of the calorie as a measure of food values was firmly established and the chief controversy which agitated dietitians concerned the much discussed "protein optimum." This had been fixed originally by Liebig at 150 grm., but was reduced by Voit to 120 grm., and this figure was accepted by Atwater. There had always, however, been physiologists who were inclined to challenge these figures as too high and Chittenden in his book, *Physiological Economy in Nutrition* (1905), showed that health and activity could be maintained for indefinite periods on as low an intake as 55 grm., and Hindhede subsequently went even lower. It was reserved for the work of the present century to show that the quest of a protein optimum is illusory, for it varies with the kind of protein consumed. The real protein minimum could only be attained by cannibals consuming solely a form of protein identical with that in the human body, but so far as we are aware no observations on the protein consumption of cannibals have been made; it might, perhaps, be risky to attempt them!

If the nineteenth century was the quantitative epoch of dietetics the present century has so far been a qualitative epoch. Attention has been shifted from the amount of the different food constituents required for satisfactory nutrition to the influence of the "imponderables" of the diet in health and disease. This has necessitated the abandonment of the chemical and physiological methods of approach for the biological, that is to say the influence of the diet as a whole on the whole animal. Stark, as we have seen, had already foreshadowed this method in the experiments he made on the effect of different diets on himself towards the end of the eighteenth century. Paris also showed more than an inkling of the importance of qualitative considerations when he wrote in 1837: "Those bodies which have possessed life can alone be strictly considered capable of affording aliment to animals; yet there exist a certain number of inorganic substances, such as water, salt, lime, etc., which, although incapable by themselves of nourishing, appear, when administered in conjunction with the former, to contribute essentially to nutrition." These he called alimentary "adjectives" as opposed to alimentary "substantives" or true foods.

Research in recent years into the qualitative aspects of the diet has met with success in three chief directions. First, it has shown that the proteins differ greatly in their biological value depending upon the amount and kind of the amino-acids composing them; second, and most important, the existence of "accessory food substances" or "vitamins" has been brought to light; third, the significance of the mineral constituents of the diet and especially of calcium, phosphorus, iron, and iodine, has been clearly demonstrated. Of these advances the discovery of the vitamins has been by far the most spectacular. The time has not yet come to write the full history of this brilliant chapter in dietetic research, but the chief milestones have been the discovery by Eijkman towards the end of last century that beri-beri is a deficiency disease; Hopkins's feeding experiments on rats, published in 1912, in which he showed the importance of "accessory food factors" in normal dietaries; the introduction soon afterwards of the term "vitamines" (afterwards changed in 1920 to vitamins) by Funk; the production of scurvy in guinea-pigs by Holst and T. Frölich in 1907; the discovery of "fat-soluble A" by McCollum and Davis in 1913 and of "water-soluble B" in 1915; and the proof by E. Mellanby in 1919 that rickets is due to a vitamin defect in the diet. The War gave a great impetus to the study of the qualitative side of dietetics by providing "biological experiments" on an enormous scale and our knowledge of the "accessory factors" has grown rapidly ever since.

Just, however, as the importance of the calorie was over-estimated at the end of last century, so the vitamins are probably being overvalued to-day. They are not, any more than the calorie value and protein content, the only criterion by which to assess the worth of a diet. It is possible, also, that too much importance is now being attached to the mineral constituents—perhaps a reaction from their neglect (in spite of the writings of Bunge) during the quantitative epoch. Their recent emergence into notice has been the result mainly of the work of McCollum and Sherman in America and of Orr in this country.

What direction the future progress of dietetics will take it is impossible to say. It is probable that more "vitamins" will be discovered or that those already known will be further subdivided. New "accessory food substances," not vitamins, but comparable to the "hæmatogenous principle" of the liver, may also be brought to light. It is unlikely, however, that Nature holds many dietetic surprises up her sleeve, and it is difficult to believe that progress in the next seventy years from now will equal, either in variety or extent, that which has been made since the middle of the Victorian era.

PART ONE

DIET IN NORMAL LIFE

CHAPTER I

INTRODUCTORY. DEFINITIONS, DIFFICULTIES, LIMITS OF ERROR AND ACTION IN DIETETICS

Dietetics is a subject which springs into prominence whenever there are wars and their consequent famines and pestilence. The war of 1939–45 is no exception; in fact more prominence has been given to dietetics than ever before, both by combatant and non-combatant nations, their governments, army and national commissariats. Thus Eire has experimented in dietetics, making 100 per cent. extraction of the wheat-berry compulsory and then some years later lowering this figure to 85 per cent. because " wholemeal " conduced to rickets. In Great Britain a flourishing and active society, the Nutrition Society, has been formed under the stimulus of war conditions and doubtless has, and will have in the future, great influence upon the collection and distribution of hypotheses, facts and information about nutrition.

It will be noticed that the term " nutrition " is beginning to oust that of dietetics, for it is felt that the term " dietetics " is narrowing in meaning and becoming that of the treatment of illness by special foods. Originally the word diet meant " a way of life " especially concerning food and dress; also it could mean a dining-room or a summer-house. In 1800 the term meant " a systematic view of all objects relative to health in general and to food and drink in particular "! The restriction of its meaning to the science of food and drink in particular was complete when this book was first produced, but by now it has become still further restricted, or rather, is in process of becoming restricted to the treatment of disease by modification of the diet. This is almost inevitable, for until now almost the only way of earning a living for those who had made a scientific study of food and drink was in the diet kitchens of those hospitals in this country which had followed the transatlantic example of recognizing dietary treatment as a part of curative medicine. The same distinction is in evidence in the United States, for McCollum and his colleagues call their book *The Newer Knowledge of Nutrition*—not of Dietetics. Nutrition therefore means the study of food and drink in all its aspects; dietetics is coming to mean the use of this study in curative medicine. That is not the meaning the authors give to the word in this book; they use it in the sense that Sir Robert Hutchison gave it—they can hardly alter the book's original title—viz. the study of food in its relation to human need. In this book the practical aspects of nutrition will always be allowed to outweigh the severely scientific. Thus the authors are not so much interested in the chemistry and distribution of some recondite vitamin as in the practical difference to living which that knowledge might make.

The applications of our knowledge of nutrition are numerous and far-reaching. They touch not only the care of the sick, but the feeding of the well. They concern public health at most points—no health authority should be without its dietitian. Community feeding, whether in schools or factory canteens, needs dietetic supervision. Educational authorities cannot afford to be without advisors trained in dietetics. This subject runs in closest contact with agriculture, and therefore with politics, alas. It should have, and will have in any stable future, a great influence upon world politics.[1] In fact each year opens up new horizons in dietetics.

But while we welcome this expansion of the influence and applications of dietetics we have sundry warnings and reservations to make, and the rest of this chapter will be concerned with these. Most of us have recollections or knowledge of what happens in a gold rush. Much the same happens in any new territory opened up by science. Adventurers, good, bad and indifferent, rush in, and the ore they bring back is often anything but auriferous. Great caution is advised in accepting glitter as authentic fact. Further—to change the metaphor—the subject of dietetics is developing so rapidly that change of perspective alters the relative size and importance of a discovery. Old dogmas disappear. New ones, alas, arise. In fact, to quote Stefánsson, the Arctic explorer, "Unless it be religion, there is no field of human thought where sentiment and prejudice take the place of sound knowledge and logical thinking so completely as in dietetics."[2]

Now dogmas have no place in science. In fact the main duty of a scientific man is to do his utmost to pick holes in his most cherished beliefs. This is essential for the dietitian, if he wishes the study he has taken up to become a science, still more an "exact science".

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[1] ORR. (1943), *Food and the People*. The Pilot Press, London.

[2] STEFÁNSSON. (1921), *The Friendly Arctic*, 191.

In the section on the History of Dietetics with which this book opens, there is a statement that needs some definition and qualification. It is: "The effect of this work on dietetics [the work of Carl von Voit and his school] was immediate and it is from this time that it [dietetics] can fairly claim to be regarded as an exact science." Most good work in dietetics springs from Voit, for he was the first to apply the exact and elaborate methods of physics and chemistry to the study of nutrition, but Voit himself would have been the first to deny that the exactitude which physics can employ in weighing a non-living substance or chemistry in estimating the atomic weight of an element can be achieved in the science of nutrition. Why, the very weight of a 2-kilogramme Belgian hare changes by several decigrammes during the process of weighing, as one of us saw in Voit's own laboratory. How much more difficult, then, must it be to weigh a man with an accuracy of 1 in 20,000. Such an accuracy is, of course, far beyond what is ever claimed in dietetics, but it must be recognized that when an argument or theory is based on the fluctuation in weight by a few grammes, an error of 1 in 20,000 in a 70-kilogramme man's weight may involve a final error of 1 in 10 or even 1 in 1!

Because the layman has such exaggerated views of the capabilities of the dietitian and the exactitude of dietetics it is perhaps worth while thus early in the book to set out its limitations, and the factors which prevent its ever becoming so exact a science as physics or chemistry.

We are met at the outset with the difficulty of **definition.** This, however, is not surprising. Is it not said that the physicist Tait had some twenty definitions of matter in his famous text-book of physics and that the best of them was, "that which is a permanent possibility of sensation"? Our definitions of "food" and "dietetics" will be almost as unsatisfactory. Voit in Hermann's *Handbuch der Physiologie* defines food as a "palatable mixture of food-stuffs which is capable of maintaining the body in an equilibrium of substance, or capable of bringing it to a desired condition of substance." The reader will note the intrusion of the word "palatable," which introduces into the definition a whole range of imponderables from the realms of psychology. Is a food less a food when it is not palatable? Is cod-liver oil not a food because it was unpalatable to most Victorians and Edwardians? And is it a food only to the neo-Georgians who have been brought up to take it from their first month of life? Is it "not-a-food" when it is concentrated, and a food when it forms an ingredient of a palatable fish sauce or savoury ?

If we want dietetics to be an exact science it must dispense with psychological considerations[1] or at least delimit their relations to and intrusions into dietetics. We offer the following definition of food : anything which, when absorbed into the body via the alimentary tract, is capable of doing one or more of three things, (i) furnishing the body with material from which to produce heat, work, or other forms of energy, (ii) enabling it to grow or to repair its wear and tear, and (iii) supplying regulators of its functions of growth, repair, and production of energy. Thus milk is usually called a food, and is to the dietitians the food *par excellence*. It can be used to supply energy in the form of heat and work. The combustion of the materials of 1 pint of milk in the cells of the body would yield energy equivalent to 378 kilocalories. It promotes growth in the body and repair. Milk also contains some thiamine, some riboflavine, some nicotinic acid or possibly nicotinamide, much vitamin A, a little ascorbic acid, and, in summer, vitamin D. All these substances are catalytically concerned in the production of energy in the cell, and, without them, it must die. On all three counts milk is to be considered a food. Other foods, e.g. the lemon, will come into consideration practically on the third count only. Its contribution to body building is infinitesimal ; to production of energy, negligible ; only because of its marked power of supplying vitamin C is it included in the category of a food.

Our definition is as unsatisfactory as all definitions of fundamental ideas are, but at least it is less open to criticism than those which have preceded it.[2] It is difficult to exclude substances which can be metabolized when injected under the skin or into the blood and yet they are excluded by the above definition, which none the less permits the inclusion of drugs. It brings into prominence, however, the three main functions of food. Food provides the materials for growth and repair of the fabric of the body. It supplies materials which can be oxidized in the body, with the result that the energy set free by oxidation may be used in performing work and in producing heat. It also supplies the body with substances (catalysts, food hormones, vitamins) which control, though present in almost inconceivably minute amounts, the various processes of the body. Food is responsible for the conservation of the material of the body, for the maintenance of its output of energy and for the regulation of these functions.

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[1] RENNER (1944) in *The Origin of Food Habits*, Faber & Faber, London, protests against this exclusion of psychology from dietetics, much as Ruskin years ago exclaimed against its exclusion from economics, possibly with similar justification. We shall deal with this later.

[2] To show how difficult it is to devise an adequate definition, let us take the examples of tea, coffee, cocoa, and meat extracts. In common parlance they are foods. But to the biochemist tea and coffee are almost certainly not foods, whereas cocoa certainly is. Meat extracts creep in on the score of their nicotinic acid. All come into the net of our definition.

We need not worry, however, about the logical unsatisfactoriness of our definition of food, except perhaps when dealing with the layman. "But tell me, Doctor," he says, "are not turnips good food ? Have not onions a high food value ?" We cannot answer his questions until we discover whether he means by food what a dietitian means ; whether he is aware that food has a threefold function, and which of the functions, if any, he has in mind.

At this point it may be well to inveigh against the vague terms which have invaded popular and not so popular dietetics. Dietetics can never become an exact science while such terms as "food value," "balanced diet," "nourishment," "malnutrition," etc., go undefined. If "food value" is used of a food to mean its quantitative yield in body-building material, in energy value or in vitamins the term is a useful one ; but if, as is usual, it means "this food is, or is not, commonly used by people" it is useless—in dietetics. "Balanced diet" may have a meaning to the dietitian, though how one can pretend in the present state of our knowledge that there is a right and proper equilibrium between protein, fats, carbohydrates, the six or ten essential metallic and non-metallic elements and the six, seven, or more vitamins, and that we know that balance passes comprehension. Probably the term means, if used by the scientific dietitian, a diet in which no particular one of the groups of substances enumerated in the preceding sentence is in defect or excess. Thus if there are no carbohydrates, or only 5 milligrammes of iron per day, or 300 milligrammes of calcium, or 100 international units of vitamin B_1 (thiamine), or 20 or 20,000 international units of vitamin D, we might justifiably say that the diet is unbalanced. If the term "balanced diet" means no more than a good all-round diet, then we can have little quarrel with it. But it has an air of exact science and is used by the charlatan to deceive the layman, and even the elect. It is significant that a search for such vague terms, with the unfortunate exception of "malnutrition," shows that they are not used in modern text-books of dietetics. They can be utilized as a danger signal, warning one of charlatanry, much as the spelling of protein as "proteid" and the use of "albuminoid" stamps a book on dietetics as being out of date.

A definition of dietetics is that it is the science of applying the hitherto discovered facts about food and its use in the body to the feeding of the individual, the family, and the nations. There is no finality about dietetics, for though much has been discovered about food, much remains to be discovered. Until about 1900 all the emphasis in dietetics fell upon Calories. It then shifted to the proteins. Thence to the vitamins and the mineral elements. To-day we say with Sherman that dietetics stands foursquare upon Calories, proteins, mineral elements, and vitamins, and it is only with an effort that we can imagine that there may be still more legs for dietetics to stand upon. Instead of being a quadruped it may become even an octopod or a centipede. Who knows ? That it is altering in detail is seen from the dethronement of spinach as a source of calcium and iron to the body. The whole of the calcium (595 milligrammes per 100 grammes) in spinach may be sterilized by the oxalate present and it has been shown that tomatoes with only $\frac{1}{9}$th of the iron of spinach yield more iron to the body. Pediatricians accustomed to give sieved spinach for iron to a baby six months old must revise their training. And as dietetics alters in detail so may it alter in gross. We dare not, as dietitians, dogmatically claim any finality in the subject. One dogma after another is discarded (e.g. the danger to kidneys of a high protein diet when the blood urea is within normal limits, the need for a low Calorie diet in fever, the value of roughage in all types of constipation) as sound reasoning and experimentation take the place of prejudice and custom. We must approach the science sceptically and with a readiness to throw overboard our most cherished dietetic beliefs. Dogmatism about food is an excellent danger signal of the presence of ignorance and charlatanism.

Probably the feeding of the individual as compared with that of the family and the nation claims most attention in dietetics ; partly because dietetics unfortunately in this country is used more in treatment of ill health than in preservation of health, and partly because we are all egoists and more concerned with our own bodies than with those even of our children. The Victorian parent regularly sent, and the rich parent frequently to-day sends, his offspring to boarding-schools where the diet was and sometimes still is such as he would not give to his servants. (Things in that respect, however, are improving and even the most famous public schools are beginning to consult the dietitian.)

In one way attention to individual diets is an advantage. A child, whatever its age, should be considered as an individual and not lumped in with the rest of the family. The custom has grown up in dietetic work in Great Britain of considering the family as a whole, in which a child of, say, 5 years of age counts as some fraction of an adult male for all his needs. That plan should be abandoned. A pregnant woman is not a non-pregnant woman multiplied by some factor; dietetically she is a different individual altogether. A child of 5 may need more calcium than an adult and a boy of 14 certainly does. Consequently, though the family is the catering unit in this nation and is likely to remain so, the family considered dietetically consists of a number of units each with its own individual wants as regards proteins, Calories, mineral elements, and vitamins.

This again applies to the nation. You have not solved the problem of the feeding of the nation when you have supplied, let us say, sufficient Calories and protein, though you will have gone a long way in that direction. You have not solved it till every individual has had a sufficiency of all the desiderata in diet—proteins, Calories, mineral elements, and vitamins—has had in fact an optimum diet, i.e. one which gives no improvement in health and growth when any of its constituents is increased or reduced in amount. How far we are in Great Britain—indeed in the world—from that position will be seen in the sequel, though it must be said emphatically that there is no reason, save gross ignorance, sloth, and a touch of poverty, why we should not, at any rate in this country, be properly fed. It is the function of the dietitian to see that we all are properly fed. There are three types of dietitians apart from other people engaged in nutritional work. They are:

(i) ***The Hospital Dietitian,*** whose work is in the wards and out-patient departments of hospitals, adjusting the protein, Calorie, mineral elements and vitamins of a diet to the needs of patients and demonstrating and explaining to patients how to carry out in the home the preparation of diets given in hospital.

(ii) ***Dietitian-caterer,*** whose work consists of large-scale catering in institutions such as boarding-schools, hospitals, infirmaries, school and factory canteens. In the past and for the most part in the present this work has been carried out by caterers with no dietetic training.

These two classes of dietitians have been and will be naturally recruited from among nurses and graduates of colleges of domestic science. There is a great and growing demand for caterer dietitians.

(iii) ***Public Health Dietitians.*** Attached to the Ministries of Food, Health, Education and Agriculture and to the local authorities in Health and Education there should be, and in a few cases already are, dietitians trained in the science of nutrition to a research standard, whose duty should be to advise those Ministries and local authorities concerning the nutrition, present and future, of the People. The Hot Springs Conference of the United Nations, 1943, definitely recommended that all public authorities should have such an adviser attached and that his training should be in the highest degree scientific and of a research nature. The recruits for this type of work are those with University degrees in science—particularly physiology and chemistry. During the war of 1939–45 the Ministries of Food and Health secured the help of several such dietitians and doubtless in the future this class of dietitian will be increasingly needed and utilized.

There are two main reasons why dietetics as applied to the individual, the family, and the nation suffers from a condition of inexactitude. The first is the varying composition of food or even of its individual parts. No one piece of bread has the same analysis as any other piece. The red side of a strawberry has more ascorbic acid in it than the white side. The outer leaves of a cabbage have more calcium and pro-vitamin A than the inside leaves. Consequently unless we analyse a sample of what is being eaten by the person investigated we cannot be sure what he is actually getting. Thus the number of Calories obtainable from a pound of white bread varies from 1037 [1] to over 1200; [2] in other words, the error of taking one figure rather than the other is about 15 per cent. In the daily diet of a working-class man the difference per day might easily be 200 Calories or about 7 per cent. of the day's total. Governments and food faddists have fought the dietitians for less.[3] Nor is it different with the protein content of bread. Figures from 7 to 10 per cent. are given, and judging from analyses made on bread from London bakers this may happen in bread purchased in the same locality.[4] As this may lead to an uncertainty concerning 13·5 grammes of protein out of the day's total of 80 to 100 grammes, the uncertainty is of the order of 13–17 per cent. Such uncertainty hardly belongs to an exact science.

Nor is this all. The protein in bread is estimated by estimating the nitrogen present and multiplying it by a conventional figure —usually 6·25. This assumes that proteins have 16 per cent. nitrogen in them. This is untrue. Some have more and some have less. The conventional figure 6·25 is far from the true figure for egg albumin (6·45) or for edestin (5·38). Thus according as the higher conventional figure or the more accurate lower figure has been used by the analyst there will be a difference of over 10 per cent.

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[1] 1037 is the figure in PLIMMER. (1921), *Analyses and Energy Values of Foods*, H.M. Stationery Office.

[2] 1216 in ABRAHAMS and WIDDOWSON. (1937), *Modern Dietary Treatment*, Baillière, Tindall & Cox. In MCCANCE and WIDDOWSON, M.R.C. Spec. Report, No. 235, 3rd ed. this has been corrected to 1088.

[3] Rubner versus the German Government during the War of 1914–18. (1916, 1917, 1919), *Arch. f. Physiol.*

[4] Unpublished figures by W. M. Clifford.

In the calculation of Calories conventional figures instead of the accurate figures have been used. Thus all carbohydrate is lumped together and it is agreed to say that each gramme yields on oxidation in the body 4·1 kilocalories. So if a food, say a sweetmeat weighing 10 grammes, consists mainly of glucose, its estimated caloric value will be 10 × 4·1 = 41 kilocalories, whereas the actual value is 10 × 3·75 or 37·5, i.e. nearly 10 per cent. less. With the decrease in the consumption of starch (4·12 kilocalories per gramme) which is taking place to-day and the increase in cane-sugar consumption (3·95 kilocalories per gramme) there results a small over-estimate of the calorie consumption if we accept the conventional figure 4·1.

The figure for protein (4·1 kilocalories per gramme) and that for fat (9·3) are both of them conventional. *Which conventional figures are used must be stated by the analyst and dietitian.* In the calculations made incidentally in the course of this book, Rubner's conventional figures, as given above, will be used. There is no guarantee that the authors quoted will have used the same convention.

If other uncertainties are to be enumerated we may point to the fact that "fat" in a food analysis usually means "petrol ether soluble substance" or even "ether soluble substance." This is certainly not always fat and not always metabolizable. The nitrogen of foods does not always represent protein, and the carbohydrate may include (though not in more modern analyses) indigestible and therefore unmetabolizable material. In fact, in any analysis of food and in any estimate of the intake of proteins, fats, carbohydrates, Calories, etc., by a person on a known diet there is an unpleasantly large margin of uncertainty, an inexactitude which we wish were not there. We cannot help it. Life and money are too short to achieve accuracy in dietetics, and we must be content with saying that A's diet contains the possibility of yielding 3000 kilocalories approximately. The approximation certainly does not lie within 100 kilocalories, so that in accepting 3000 kilocalories we are assuming no more than that the true value is probably between 2900 and 3100. The estimation of a diet's values to more than the second significant figure is absurd. There is thus, in the analysis tables which are the basis of our calculations in dietetics, an uncertainty and inaccuracy which may be daunting to the neophyte and must be devastating to one "hot for certainty in this our life." But as long as it is recognized and allowance is made for it, it is no bar to the usefulness of dietetics.

There is, however, a second ground for inexactitude in dietetics and that is to be found in the extreme dietetic variability of the human race. We can make average estimates; we may lay down average "laws" for the feeding of people: their basal metabolism varies as a function of their surface area; the average man needs so many Calories per day and the average woman so many less. We may speak of average figures, but if we apply these figures to the individual we are lost.

Two good illustrations came to light as the 9th edition of this book was being prepared; the one in an article in the *British Medical Journal* [1] and the other in a book upon Mass-observation.[2] The former is that of a boy, son of vegetarian parents, who at 9 years of age weighed 4 stone 3 lb., was 4 feet 2 inches in height, and was intelligent and energetic. His diet included but little animal protein—cheese and milk—the nitrogen output was low (about 4½ grammes per day, equivalent to 28 grammes of protein) and his Calorie intake 800 daily. This boy's height was normal for his age, though he was 10 lb. underweight as compared with the Christ's Hospital figures.[3] Yet he seemed fit and healthy, though his protein intake was not half the normal and his Calorie intake about one-third that recommended by the Technical Commission of the Health Committee of the League of Nations.

The second example was that of an all-in wrestler, a champion. "And he says that to get that feeling [i.e. that you want to tear the other man into little pieces] you have got to eat meat and plenty of it. He buys a whole joint at a time. He eats whenever he feels like it, not at any fixed time. Once he tried a vegetarian diet for six months. He wanted to try it and see if it was good for him. He found that it made him feel fitter than ever before in his life, but, as he puts it, 'I didn't seem to have that little bit of fire.' So he came back to meat in the end."[4]

Again, the capacity for absorbing the nutrients in food may vary. Thus McCance and Widdowson have shown that on the same diet one person may be in positive calcium balance and another in negative balance; and Meulengracht that the use of purgatives may prevent the absorption of calcium. One of us (G. G.) has a patient whose apparent need of vitamin C is three times the average need. Such instances could be multiplied indefinitely.

[1] LEONARD HILL. (1938), *Brit. Med. Journ.*, **2**, 417.

[2] *Britain by Mass-observation.* (1939), 127.

[3] FRIEND. (1935), *The Schoolboy.* Heffer & Sons Ltd.

[4] *op. cit.*

With such contradictory evidence one might reasonably ask whether there is any reliance to be put in quantitative results. There certainly is in average figures, but they must not be taken too rigidly. It would be wrong to say to either of the people quoted above that he must change his diet to bring it nearer the normal, and also wrong to say to the average man that he must imitate either vegetarian boy or meat-eating wrestler in departing from the normal. Even in carefully collected data on individual intakes in food we find extraordinary departures from the mean. In the case of men, the Calorie figure per day varied from about 1800 to 5000, and the figure for women from approximately 1500 to 3100. The figures for total protein, animal protein, fat, carbohydrate, calcium, phosphorus, and iron varied from one figure to another nearly its double. There was no significant correlation between Calorie intake and body weight. Nor did there seem to be any relation between occupation and Calories on the one hand or between Calories and the percentage surplus or deficit in weight. A person might be overweight for height and far below the average Calorie intake, or be normal in weight and yet take 5000 Calories.[1] Similar variations, though with not so large a spread, were found for women.[2]

All these departures from the mean or average figure are not adduced here to cast discredit upon dietetics, but to check the too eager student of the subject from applying the average rules which have hitherto been discovered in dietetics ruthlessly to all people. Dietetics is by no means "totalitarian" in its "laws"—in fact, very much the reverse. It lays stress, or should lay stress, upon individual requirements and personal peculiarities and idiosyncrasies. Perhaps some day we may be able to explain why, in the research quoted above,[3] one subject, a university teacher of 28 years, is slightly overweight on an intake of 1772 kilocalories per day, while another subject, an electrician one year older, obtains 4955 kilocalories per day from his food and is not overweight. At present we have no explanation and it is a disservice to the science of dietetics to pretend that we have.

Dietetics, though fundamentally quantitative, has difficulty with the extreme variability of the individual. Nevertheless there are rules and quantitative rules for the majority, just as there are laws for the behaviour of the molecules in a gas if we take them in quantity. And just as physics discovers that the behaviour of individual atoms and molecules is unpredictable, so too in dietetics the individual may have a behaviour wide of the mean.

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[1] Widdowson. (1936), *Journ. Hygiene,* 36, 269.

[2] Widdowson and McCance. (1936), *ibid.*, 36, 293.

[3] Widdowson. *loc. cit.*.

That this individuality in practice in dietetics is partly due to psychological make-up is fairly certain. The aphorism "one man's meat is another man's poison" has often been used to justify the refusal to eat a specified food. Doubtless the aphorism is not meant dietetically, but if it is, in most cases it is emphatically not true. Only with the allergics can a definite food be termed a poison. An asthmatic who is sensitive to egg-white or to cheese is justified in calling egg-white and cheese poisons to him. Cow's milk may cause an allergic child to get eczema, and cow's milk may certainly be termed "poisonous" to such a child; dermatologists who naturally see a great deal of allergic eczema may be inclined to believe that cow's milk is a poison. But the case of allergics is no definite ground for proclaiming that "one man's food is another man's poison," for the percentage of allergics in the populace is not high, though they make themselves heard, particularly those prone to hay-fever. What the phrase means is that what one man loves to eat is hateful to another, and of that there is no doubt. We have all met people who aver that they cannot touch this food or that and inflict their likes and dislikes upon their friends and relations, often with an odious and unctuous rectitude.

It will be worth while to examine these likes and dislikes of food, for they circumscribe very severely the practice of dietetics. It is not much use giving even the best of foods to a sick person if he has an aversion from it; a second-rate dish, if he likes it, will actually "do him more good" as the phrase goes.[1] It is not much use trying to feed a school dietetically if what you serve at table goes into the pig tub. The practice of dietetics is severely conditioned by food habits.

In the first place these food habits are not instincts. More and more we are coming to the belief that when man took to reason he scrapped instinctual guidance. Certainly there is evidence for this in dietetics. If instinct in the matter of food were at all paramount such things as deficiency diseases—scurvy, rickets, and beriberi—would be unheard of. Rickets was rife in Elizabethan days before any industrial revolution. We were a seafaring race. But did instinct tell our sailor forebears to consume fat fish and cod livers? On the contrary some physicians associated living by the sea with rickets. Up till 1800 scurvy was a common late winter and early spring complaint in England, but did instinct tell our fathers to eat the potato which was certainly introduced into Europe in the sixteenth century? Instinct does not tell the Akikuyu to eat more of the foods which would give him strength and stature, though tribal custom does, interestingly enough, allow the woman more of the foods which supply calcium than the man —a possible adjustment of diet to child bearing.[1] Instinct does not lead the Eskimo in contact with white folk and therefore inclined to adopt his food to eat the salmon berry,[2] which might prevent his getting scurvy. He has to be taught to do so.

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[1] Marie Lloyd. "A little of wot yer fancy does yer good." Edwardian music-hall song. As an example of this we quote Polly, a girl aged 8 with dropsy due to heart failure. She had vomited all the carefully chosen food given to her for several days. In despair the physician said she might have what she liked. Polly chose, and was given, fried sausages. She was not sick and from that day began a rapid recovery from the dropsy. Such exceptions prove (i.e. probe) the rule.

In fact, unless it be in the matter of Calories, instinct is a poor guide to the right food. It tells us nothing about the amount of first-class protein, nothing about the mineral elements, nothing about the vitamins needed per day. And this is true too of domestic animals such as the dog and the laboratory rat.[3] The puppy has to be taught to eat meat[4] and the laboratory rat can be fooled as to what food "did him good." Instinct does not guide.[5]

What probably enables a rat to choose the diet with vitamin B_1 in it as against one which is deficient, while he cannot do so when vitamin A is in question, is the euphoria which results on taking the right B_1 diet. We have a euphoria as the result of taking alcohol or other drugs such as morphine, cocaine, or heroin, but the euphoria is no proof, though it is often accepted as such, that such potions are doing us good. The fact is that food-likes and dislikes are largely habits, conditioned reflexes, learnt automatic reactions and have little or nothing to do with instinct, defence mechanisms, and so on.

It is a commonplace that we can learn to like a food which has at first filled us with nausea. To the English the eating of green olives is an "acquired" taste; eating black olives still more so.

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[1] ORR and GILKS. (1931), *Medical Research Council Special Report Series*, No. 155.

[2] STEFÁNSSON. (1921), *The Friendly Arctic*, Macmillan & Co., 63.

[3] HARRIS, CLAY, HARGREAVES, and WARD. (1933), *Proc. Roy. Soc. B.* **113**, 161.

[4] PAVLOV. *Conditioned Reflexes.*

[5] RICHTER (1942–3), however, strongly opposes the views here set forth. *Harvey Lect.* 38, 63. Also RICHTER, SCHMIDT and MALONE. (1945), *Bull. Johns Hopkins Hosp.* 76, 192. Cited *Lancet*, 1945, 2, 467.

Some of us can remember acquiring the taste. To the Spaniard the acquirement comes so early in life that olives appear to be an obvious and natural food. Similarly tastes for food may be lost and distaste take their place. Stefánsson has a story of a sailor who had acquired a distaste for fat in early life. He had stolen some fat, was made by his mother as a punishment to eat a large quantity of it, became violently ill as a result and thereafter " could eat no fat." Many of us can match such an observation. A food may have been the cause of or accompanied some alimentary upset and after that that food tasted unpleasant. The upset need not be alimentary. It can be emotional. A child may connect some food with discipline from parents and not be able to eat it for the rest of his life.

Naturally these food habits are usually acquired in early life. What one is brought up to eat, that one likes. As Stefánsson puts it, bread seems a natural article of diet to a Western civilization, and rice something that one eats occasionally. To an Eastern civilization rice seems to be the natural " staff of life " and bread a not very interesting adjunct. The rice-eating Bengali in 1944 preferred to starve to death rather than eat wheat flour. In various books and articles Stefánsson has shown this principle to be working amongst his colleagues in Arctic exploration, the Eskimos he met, and the dogs who drew his sleighs. Of his colleagues, the University men were the most willing to change their food habits. To eat meat and little else for a year was an adventure--it attached itself to a conditioned reflex (adventure) and became part of it. To those who had been brought up on but a few foods it was a hardship to live entirely on meat. They hankered for bread and flour, with disastrous results in one case. It was the same with the Eskimos. They would not eat what they were not accustomed to. The males were less conservative than the females ; the children were experimental but always checked by the females. Among the dogs it was the same. Dogs brought up on fish had to be starved into surrender before they would eat caribou (deer) ; dogs brought up on caribou had to be starved into surrender before they would eat game ; and so on. Fortunately if the food were allowed to go putrid dogs would eat it whatever its source. The females had stronger new food " resistance " than the males. Among human beings and dogs it is the females who teach food habits to the young.

The wonder is that any food habits change, for there is a circle " what-one-eats-when-young,-that-one-likes-and-hands-on-to-one's-offspring " which theoretically should rotate for ever. Fortunately there are progressive and rebellious spirits who break away from family traditions, travel and bring home new habits. And there are the intellectuals who will not be subservient to their tastes. None the less it takes a long time to introduce a new food. It took at least 200 years for the potato to get a hold upon Europe, and the tomato a hundred years. More recently the grape fruit has conquered us in England in about 30 years and it may be that the avocado pear, the lichee, the persimmon and the grenadilla will be added to our lists of common foods more rapidly still.

All this, dietetics has to recognize. It has to realize that there are limits set upon its scope of action. It cannot be accurate to within definite wide limits because the composition of foods varies within wide limits. It cannot lay down dietetic laws applicable to everyone, because of the variation in men's needs (? habits), because some take more than their share (are pleonectic) and some take less than their share (are meionectic). It dare not impose, as most food faddists and fanatics try to impose, its discoveries concerning one man or group of men, upon all and sundry. It must realize that the psychology of the individual may play havoc with any plan of diet based even upon wide observation and that unfortunately therefore a poor diet may suit such a person better than a well-conceived diet. Although its task is to educate the general public to the belief that a food is a food only in its capacity to supply fuel, building, and regulative materials, not in its capacity to please the palate at first bite, none the less it must recognize that food habits are fairly unshakable, and that to do any immediate good it must work within the ambit of those food habits and prejudices. One part of the work of practical dietetics is to feed the sick, and this can only be done if their likes and dislikes are recognized. But another part of its work is to educate the individual, the family and the state in the best methods of feeding themselves to advantage. This will often mean the breaking down of food prejudices, and the question is where in the vicious circle of food habits to make your attack. The probable answers are (i) at the point when the mother has her first baby, (ii) sometime in adolescence when one is always hungry, and (iii) when the intellect takes charge, if it ever does, of a person's reactions.

CHAPTER II

THE FUNCTIONS OF FOOD. (I) SUPPLY OF ENERGY

Food has been defined in the first chapter as anything which, when absorbed into the body through the alimentary tract, is capable of one or more of three things, (i) furnishing the body with materials from which to produce heat, work, or other forms of energy, (ii) enabling it to grow or to repair its wear and tear, and (iii) supplying regulators, or the raw materials for regulators of its functions, of production of energy, growth, and repair. It will be noticed that this definition is *physiological*, i.e. it deals with what the foods do in the body—what are their functions. Perhaps the third function needs some explanation. There are reactions which go on in the body at a definite speed in the normal person, but in the abnormal person may go faster or slower. If the thyroid gland elaborates too much thyroxine its owner burns up fuel materials too rapidly ; if too little, too slowly. The iodine and the tyrosine from which the thyroid gland elaborates thyroxine are found in food. Similarly the oxidation of carbohydrates in the cell is directed and regulated, among many other things, by thiamine, riboflavine, and nicotinamide, three vitamins preformed in food. Without these preformed catalysts the normal processes of the body will proceed at abnormal velocities or not at all. This third function of food, which will be dealt with in Chapters IV and V, is a discovery of this century. It received its main impetus in the second decade and has almost monopolized attention in research in dietetics to the present day.

Though the outlook of the dietitian must be physiological, this does not mean that the outlook of the chemist can be dispensed with. On the contrary dietetics must keep in close collaboration with the chemist without, however, allowing his concepts to dominate the field too much. Without the chemist and the biochemist we could not have obtained any idea of the nature and mode of operation of the vitamins. They would still be mysterious somethings, the cynosure of every food faddist and quack medicine and food advertiser. The more we know about their chemistry the more accurately we can use them in dietetics.

On the other hand dietetics must keep in touch with the caterer. It is not enough to know what substances are necessary for adequate nutrition, we must know how and where to obtain them in foods and the most convenient and possibly the most economical ways of buying them. To take an extreme example: should an Arctic explorer live "off the land" as Stefánsson and the late Gino Watkins did, or should he carry food in its most condensed form from temperate climes?

The outlooks of the three types of persons interested in dietetics are here arranged tabularly:

The Physiologist. Foods are useful for—	*The Chemist.* These foods contain respectively—	*The Caterer.* These substances are found mainly in—
1. Energy production.	1. Fat, carbohydrates, and (though not so important) proteins.	1. Dripping, lard, suet, butter, margarine, cereals, sugar, dried fruits, pulses, and things made from these.
2. Growth and repair.	2. Proteins mainly, but to a less extent calcium, iron, etc.	2. Milk, eggs, cheese, fish, and meat.
3. Control, regulation, and direction of processes in the body.	3. "Mineral" elements and vitamins.	3. Dairy foods, certain specified fruits and vegetables, and the fat fish.

This classification is not perfect, nor is the alignment between the three columns perfect. For instance, although we in Great Britain obtain only about 10 per cent. of our Calories from protein and, as it were, incidentally and by accident, in the Arctic Circle perforce and among the Masai by choice, 44 and 39 per cent. of the Calories respectively are derived from protein. Whereas it would be true to say that in Europe the energy value of our diet arises largely from the fats and carbohydrates, it would not be so among the Eskimos and the male Masai. Again the mineral elements in our diet are mainly used for catalytic purposes, but (notably) calcium and phosphorus, though essential for such purposes, are also used in relatively enormous quantities for building the skeleton, with the result that the child's and the adolescent's need for calcium and phosphorus is greater, much greater, than the adult's. Further, it is true that whereas we get our energy-producing foods mainly from the grocer and baker, and the body-building foods from the dairyman, the butcher, and the fishmonger, we cannot say (as has unfortunately often been said) that we get our regulators of bodily reactions—our mineral elements and vitamins —from the greengrocer. Calcium and phosphorus we get in large amounts from milk and cheese; iron from eggs and treacle, and our vitamin D from eggs and (pre-eminently) fat fish. Nor, again, are *all* fruits and vegetables of use for mineral elements and vitamins: the grape and the pear among fruits and the marrow, to take three examples from many, being nearly worthless so far as is at present known as purveyors of these necessities. For the purpose of supplying sources of vitamin C, a vitamin relatively rare in the dietary of many preparatory and public schools, fruits and vegetables must be closely scrutinized and chosen from appropriate tables.[1, 2] Too often does one read on a school prospectus "abundance of fruit and vegetables given for the vitamins."

On looking at the third column of the table on page 17, it will be seen that some foods appear (or would appear if we could make our lists complete without overloading) more than once. For example, cheese appears as a body-builder (25 per cent. or more protein); it also appears as a supplier of mineral elements (800 to 900 milligrammes calcium and 650 milligrammes phosphorus per 100 grammes); it would reasonably, too, appear under the energy-producing foods for no less than 2000 Calories per lb. are obtainable from it. Milk too appears as body-builder (the best there is) and as supplying mineral elements (calcium and phosphorus) and vitamins (A, and riboflavine). It, too, is not negligible for energy. The herring is excellent and cheap for body-building material; fair for vitamins A and D and contains some calcium. Moreover, it can supply energy. These foods—milk, cheese, eggs, and herrings—appear then to be the most important foods from the point of view of dietetics. It is unfortunate that these valuable foods are not more used.

The Chemistry of the Food-stuffs. Any food may have any or all of the following classes of chemical substances in it:

1. Proteins, e.g. caseinogen, albumin, myosin, gluten, legumin, gelatin, etc.

2. Fats, e.g. triglycerides of fatty acids such as butyric, caproic, myristic, palmitic, stearic, oleic, linoleic and clupanodonic acids.

3. Carbohydrates, e.g. starch, dextrins, glycogen, sugar, cellulose.

4. Mineral elements either as salts or in combination with

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[1] Boas-Fixsen and Roscoe. (1937–38), *Nutrition Abstracts and Reviews*, 7, 823.

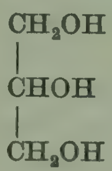
[2] Boas-Fixsen. (1938–39), *ibid.*, 8, 281.

organic material, e.g. common salt, and compounds of calcium phosphorus, potassium, magnesium, iron, and iodine.

5. Extractives and flavouring matter.
6. Vitamins.
7. Water.

We will defer consideration for the time being of any but the fats and carbohydrates, for these are the main sources of energy in the body.

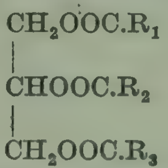
Fats. The majority of what we call fat consists of molecules of glycerol, each combined with three molecules of fatty acid. Glycerol is represented as



$$\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$

and some of the fatty acids which combine with it to form fat are butyric acid, C_3H_7COOH; palmitic acid, $C_{15}H_{31}COOH$; stearic, $C_{17}H_{35}COOH$; and oleic, $C_{17}H_{33}COOH$. Acids of the series $C_nH_{2n-4}O$, $C_nH_{2n-6}O_2$ and $C_nH_{2n-8}O_2$ may be found in the fats of foods.

Rarely is only one acid present in a fat, with the exception of olive oil, which is mainly triolein, i.e. glycerol united with three molecules of oleic acid. Generally the fats are mixed triglycerides and if we represent the part of the fatty acid in front of the COOH groups above by R_1, R_2, and R_3, the fats are of the type



$$\begin{array}{l} CH_2OOC.R_1 \\ | \\ CHOOC.R_2 \\ | \\ CH_2OOC.R_3 \end{array}$$

The fats of different animal and plant foods are different because of the nature of the fatty acids present in them. Olive oil has oleic acid almost entirely. Butter has some butyric acid. Vegetable margarines have no butyric but fair amounts of acids like caprylic. Mutton fat has palmitic, stearic, and oleic acids. Cod-liver oil and fish oils generally have many of the highly unsaturated fatty acids.

This variation of composition has some bearing on the ***dietetic value of fats,*** though but small bearing on their energy value in diet. It is true that a highly oxidizable fat like cod-liver oil will give out more Calories when oxidized than a saturated fat, but in practice this difference is neglected. We take the value of 9·3 Calories per gramme as the conventional standard whatever the actual Calorie value of the fat may be.

The Carbohydrates comprise a group of substances more unlike each other superficially than are the fats, but none the less having more likeness in the building stones from which they are made. As the term suggests, they are composed of the elements carbon, hydrogen, and oxygen, the latter two being in the proportion of two to one as in water. The elementary building stones of the carbohydrates important in food are the simple sugars containing six carbon atoms: the hexoses or monosaccharides, glucose, fructose, and galactose, and into these monosaccharides all carbohydrate foods have to be resolved by digestion before they can be of use to the body. Two monosaccharides united form the disaccharides, cane sugar (sucrose), malt sugar (maltose), and milk sugar (lactose), all of which have importance in dietetics. Starch, glycogen, and dextrins are complexes of many monosaccharide building stones (glucose in every case) and are therefore called polysaccharides. Not less than 26–30 glucose units, and it may be as many as 2000 units, are linked up to form starch;[1] 12 or 18 to form glycogen, and the dextrins have numbers approximating to that of starch and thence downwards to three; stable dextrin or trihexosan. All these polysaccharides which are condensation products of hexose sugars are called hexosans and all, or many of them, may be found in a breakfast food such as cornflakes or grape nuts. Starch grains (particularly potato starch) have a substance amylopectin in them which is a hexosan united with phosphoric acid. It confers their well-known insolubility on starch grains, and probably accounts for their indigestibility when uncooked. Potato starch has most amylopectin (73 per cent.) and rice starch least (38 per cent.), and these figures may account for (i) the fact that uncooked potato starch causes colic, and (ii) that rice is eaten in Asia in a state less cooked than is usually tolerated in this country without mishap.

Of the monosaccharides glucose is found in nature in fruits such as grapes, in vegetables, and in honey; fructose in the majority of fruits and in honey; while galactose is not found free. Cane sugar, among the disaccharides, is found in the sugar cane and sugar beet, in other root vegetables and in most fruits. The commercial product "sugar" is practically 100 per cent. cane sugar. Syrup and treacle contain 70 per cent. hexose sugars. Malt sugar is found in malt and malted products and milk sugar in milk.

Starch is present in all the cereals, in the pulses, in chestnuts, and in potatoes. Dextrins occur in manufactured foods as the result of submitting starch-containing foods to dry heat or to diastatic enzymes. Consequently the crust of bread and cakes, biscuits and breakfast foods and also the crumb of bread contain dextrins.

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[1] Richardson. (1941), *Chem. and Ind.*, **60**, 142.

Glycogen, the only carbohydrate of animal origin, is found in liver, in shell fish, and to a much smaller extent in all muscles ("meat").

In addition to these carbohydrates, which may be termed the ***"available"*** carbohydrates, because the body can utilize them as fuel, there are a number of substances occurring in fruits and vegetables which dietitians loosely and incorrectly comprise under the name "cellulose." They are plant cell-wall products. One, pectin, which is responsible for the "jelling" of jams, is a mixed colloid with a pentose, galactose or methylated galacturonic acid as the units of structure. Others have derivatives of glucose, mannose or galactose as their basic units. Neither pure cellulose nor these other substances are digestible, absorbable, or metabolizable by the body. Their only function in diet is to hurry a meal along the alimentary tract owing (i) to their mechanical action (e.g. lettuce leaves the stomach more rapidly than many a digestible food), and (ii) to the irritating effect of the chemical products of their decomposition by bacteria in the large intestine. The value of these ***"unavailable"*** carbohydrates or ***"roughage"*** in diet has been and still is over-rated. It is assumed that some roughage is essential in diet for normal people; more still for those who possess a sluggish large intestine, and it is possible that its absence from a diet is essential for those who possess a spastic colon.

The fuel value of the available carbohydrates is assessed at 4·1 Calories per gramme, although that of starch is nearer 4·2, while that of cane sugar is 3·95 and of glucose 3·75; 4·1 is a "conventional" average figure. In most food tables under the heading "carbohydrate" the figure for the available carbohydrate is given; but in older tables often the carbohydrate of the fibre (i.e. cellulose, pentosans, etc.) is included and the Calorie value is too high.

Proteins, as stated above, can be and are used by the body for the production of energy. Indeed they are used entirely for that purpose if no carbohydrate is taken along with them at a meal.[1] This is so because in the breakdown of their constituent amino-acids in the liver they pass either through a carbohydrate (glucose) stage or a fatty acid stage and are oxidized as such. A little more than half of the protein is oxidized via the glucose path and somewhat less than half goes by the fatty acid path.

The conventional figure for the ***fuel value of protein*** is 4·1 Calories per gramme. Outside the body the fuel value of protein burnt in oxygen is 5·6 Calories. The reason for this discrepancy is that the body does not, and could not without danger, burn the protein as completely as it is burnt in the calorimeter. The body oxidizes the protein to a stage in which it is safe and convenient to get rid of the end products of combustion. The bomb calorimeter oxidizes protein to carbon dioxide, water, and oxides of nitrogen (the last-named are poisonous). The body oxidizes protein to carbon dioxide, water, urea (mainly), and uric acid and other nitrogenous substances. Urea and the other nitrogenous substances would yield a considerable amount of heat if burnt in the bomb calorimeter and it should be clear, from the doctrine of the conservation of energy, that the caloric value of a protein to the body is its bomb calorimeter value minus the bomb calorimeter value of the waste products—urea, etc.—in the body. This has been investigated many times and found to be true (within the limits of experimental error of the apparatus). We may take it as beyond doubt that the doctrine of the conservation of energy is true for the human body,[1] and that the average value for the proteins consumed in the body is 4·1 Calories per gramme. Further consideration of the proteins is deferred till we come, in the next chapter, to their function as body-builders.

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[1] Cuthbertson and Munro. 1939, *Biochem. Journ.*, 33, 128.

Energy. The words energy, work and heat have been used above as though they were one and the same thing. To the layman "energy" probably calls up a picture of rate of doing work (which the scientist dubs "power"), or even a fussiness in doing work—an idea best represented by the American slang word "pep." To the scientist, on the other hand, energy is probably the fundamental reality pervading the universe, for even matter is resolvable into units of electrical energy, the prime source of energy on this earth being the breakdown of matter in the sun in its slow passage from a largish star to a heavy dwarf star. If energy pervades everything it must be protean in form, as indeed it is. It appears now as electricity, now as light, as muscular and machine work, as potential work in the high mountain lake or reservoir, as kinetic energy in the waterfall, the tides, or the turbine race, as chemical energy and as heat. And it almost follows that since energy appears now in one form and now in another that these forms are intraconvertible. We know that energy (say) of Niagara Falls may be made by appropriate machinery to appear as electrical energy throughout southern Ontario and in adjacent parts of the United States; or that energy radiated as electric waves from Daventry may activate a radio set in New

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[1] No sane scientific man ever doubted this. There could be no science of dietetics were it untrue. But it was well to demonstrate the fact for the discomfiture of the crank.

Zealand. Similarly one day the energy of the tides in the Severn estuary may be made to run machinery in, and to light, Bristol, Gloucester and Cardiff.

The source of energy of the infinitesimally small speck of planetary matter which we inhabit is the sun, which for many billion years has been radiating, and will continue to radiate for many more billion years, energy into space in the form of light and heat and other electromagnetic waves. Of this energy the earth intercepts a tiny fraction and on the use of some portion of this fraction life depends. Without energy, life is impossible. Living plants imprison energy in their seeds and storehouses such as tubers, rhizomes and roots. Animals, including man, prey upon these sources of energy. Or the plant in ages past having imprisoned energy in its tissues, dies and leaves a heritage of coal to be used millions of years later by man as a source of energy. Every muscular movement we make, whether cardiac, respiratory or mechanical, is based on stored chemical energy derivable in the first instance from the sun via the plants upon which animals prey. The physiologist can demonstrate that each drop of saliva, sweat or urine secreted requires energy. Possibly, even, though of this there is still reasonable doubt, each thought we think necessitates the expenditure of energy. All this energy comes from our food, which originally comes from plants and initially from the sun, trapped by plants and twisted to the uses of life. Consequently the study of food as a source of energy, in the strict scientific usage of that term, must be of prime importance to the dietitian.

Energy then pervades everything, appears in manifold intraconvertible forms, is indestructible, is essential to life. Through energy we live and move and have our being. Our source of energy is food, i.e. energy stored in the first place by plants from the squandered energy of the sun.

Naturally the dietitian wants to know how much energy the human body needs per day and therefore how to measure it. As all energy is indestructible and intraconvertible it hardly matters in what form we measure it, so long as we know the conversion factors from one form of energy to another. Thus when we lift one pound one foot against the pull of the earth we do one foot-pound of work. When we heat 1 lb. water through one degree Fahrenheit we put energy into the water equivalent to 772 foot-pounds of work. Knowing that factor, 772, it does not matter much to us whether we measure the work of the body in thermal units or in foot-pounds. Actually in practice we prefer to measure the daily output of energy of the body in thermal units—usually as Calories.

For this there are two reasons, (i) the figure it gives us is convenient to handle—it is expressed in thousands [1] rather than millions or billions, and (ii) all energy in the body, and elsewhere, ultimately appears in the form of heat. Our muscles contract and at once produce heat. The friction in our joints produces heat. To put our muscles into a condition where they contract again produces heat. The stone we hurl through friction against the air produces heat. In its final contact with the earth its kinetic energy is transformed into heat. Moreover the transformation of heat energy into mechanical work involves a wastage of about *two-thirds* of that energy—as heat. As the body must be assumed to work in accordance with the laws (i.e. "rules") of thermodynamics—heat and work are intraconvertible in definite proportions, and it is impossible to produce a constant supply of energy by any isolated self-acting machine—the majority of the energy of the body appears as heat. In fact if you isolate the human body by placing it in a calorimeter (see below) all the energy it puts forth *must* appear as heat. That therefore is the most convenient form in which to measure the output of energy by the body and therefore—energy being indestructible and uncreatable—the energy ***needs*** of the body. We measure the output and needs of the body for energy by calorimetry.

We have mentioned the Calorie as being the measure we adopt of the body's output or needs per day. The Calorie is the amount of heat requisite to raise the temperature of one kilogramme of water (2·205 lb.) one degree centigrade ($\frac{9}{5}$° Fahrenheit).[2] For those who think in pounds and degrees Fahrenheit, as is "natural" in this country, the Calorie is almost exactly four times the size of the "natural" British unit, i.e. the heat necessary to raise one pound of water one degree Fahrenheit.

If the body gives out heat in the course of a day which would raise either 3000 kilogrammes of water through 1° Centigrade; or 300 kilogrammes through 10°; or 30 kilogrammes through 100°; we say that the body has given out 3000 (kilo or great) Calories. This indicates that the food must supply 3000 (kilo or great) Calories to the body in the course of the day.

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[1] e.g. 3000 Calories per day instead of 1,292,000 Kilogramme-metres, 9,370,000 foot-pounds or 1,265,000,000,000,000 ergs.

[2] The actual unit of heat used by the physicist is the small calorie, or the heat necessary to raise the temperature of 1 *gramme* (not a kilogramme or thousand grammes) of water one degree centigrade—a cause of considerable confusion. The great Calorie or Kilocalorie should always be written with a capital C to distinguish it.

Calorimetry

Direct Calorimetry. There are two methods of direct calorimetry: human calorimetry and food calorimetry. ***Human calorimetry*** has been raised to a point of great accuracy. Originally the calorimeter or container was the size of a tiny room 9′ × 6′ × 6′. Such calorimeters are still in use and can contain a bed, or a table and chair, or a stationary bicycle with magnetic brakes upon which "work" may be done. The "room" has copper walls and is enclosed within three other shells, the inmost zinc and the outer two wood, all insulated from each other. A series of close-fitting doors through these shells gives access to the calorimeter and there is a window through which food can be passed to the subject or excreta passed out for analysis.

To measure the heat produced by the subject iced brine is circulated through radiators in the calorimeter. The volume of brine circulated during the experiment is weighed, and this weight multiplied by the rise in temperature of the brine, which is measured by very accurate electrical resistance thermometers, gives a measure of the Calories absorbed by the radiators. If we add to this the heat absorbed in vaporizing water in the lungs and by the skin, we have, subject to small corrections, the total heat produced by the subject during the experiment. The air in the calorimeter is purified by sucking it out with a rotary blower. It is then passed through a container with sulphuric acid in it to remove moisture, then through one with soda lime to extract the carbon dioxide, next through another container with sulphuric acid to trap any water from the soda lime, and last back into the calorimeter. As the air would be depleted of oxygen if further oxygen were not admitted there is an apparatus attached which automatically allows pure oxygen to enter from a cylinder whenever the pressure within the calorimeter falls to an appreciable extent.

The apparatus thus measures not only the heat given out during the course of the experiment but also the oxygen absorbed and the carbon dioxide and water given out by the subject. We can, from these data, together with the nitrogen excreted by the kidneys, calculate what materials have been consumed in the body of the subject during the experiment.

We can also, if the subject spends a long time in the calorimeter, compare the heat he gives out with the theoretical amount he could get from burning the food he has eaten. This must be, as explained above, the heat obtained from oxidizing the food in oxygen minus the heat obtainable from oxidizing the excreta in oxygen. When the experiment is made, as has been done many times, it is found that the directly observed output of calories equals almost exactly that indirectly calculated. The difference between the two is within the error of experiment. In fact the difference is about 0·2 per cent.

Modifications of such calorimeters are in constant use in the richly endowed hospitals of the United States, and for further information the reader is referred to Du Bois' book [1] on Basal Metabolism.

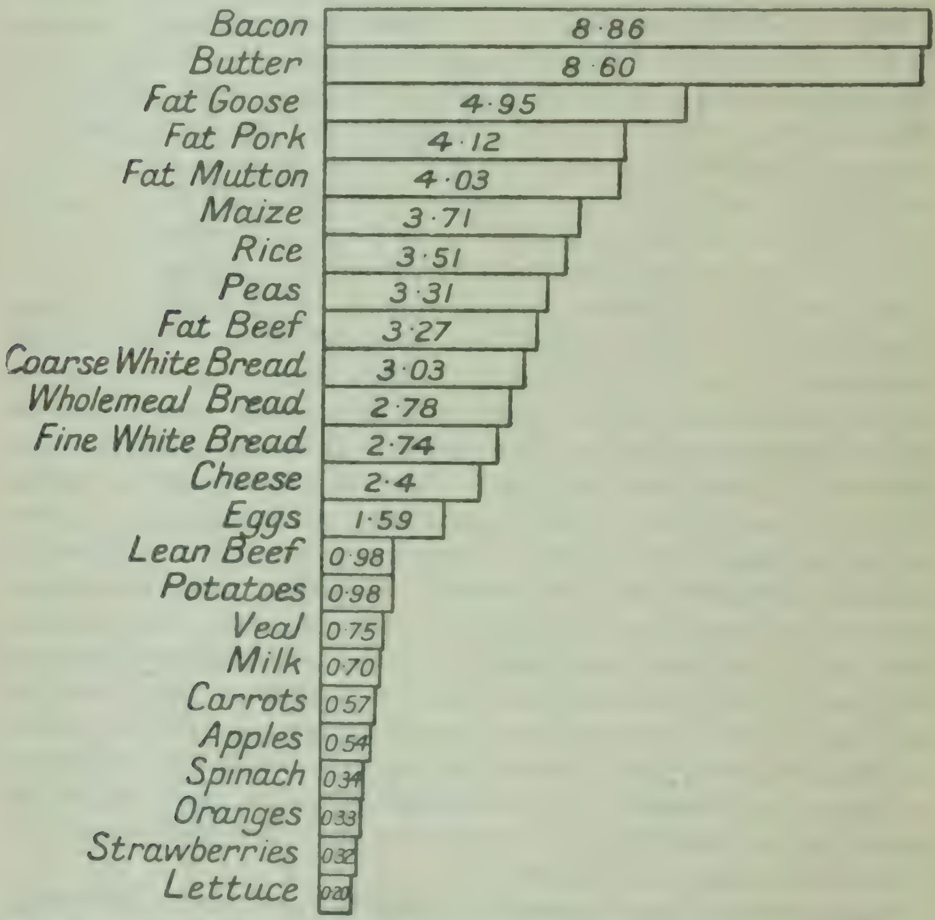

FIG. 1.—NUMBER OF CALORIES YIELDED BY THE COMPLETE COMBUSTION OF ONE GRAMME OF VARIOUS FOODS.

Calorimetry of food—in which the food is burnt outside the body in a calorimeter—is usually carried out in the ***bomb calorimeter***. This consists of a thick-walled nickel steel vessel in which a fifth of a gramme to a gramme of the food under consideration is burnt in oxygen under considerable pressure.[1] The food is placed in a platinum crucible, and lowered into the bomb, the bomb is closed by a massive accurately fitting screw plug, oxygen under several atmospheres pressure is admitted through a small vent into the bomb, which is then closed. The whole is lowered into a metal calorimeter filled with water. When the temperature of the water becomes constant, the food is fired by means of electrical leads passing through the stopper of the bomb, the food burns instantly to carbon dioxide, water, and oxides of nitrogen with evolution of heat. This heat passes to the water of the calorimeter and the rise in temperature of this water, subject to many corrections, gives a measure of the Calories given out when the food is combusted.

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[1] DU BOIS. (1936), *Basal Metabolism in Health and Disease.* Baillière, Tindall & Cox.

As explained above, the figures for fats and carbohydrates are the same for combustion in the body as in the bomb calorimeter; but for proteins a considerable amount less is obtained by the body because it does not oxidize protein so completely.

In the same way the Calorie value of the excreta produced during long experiments on animals or human beings can be obtained. The substances are dried, powdered, and aliquot portions of about half a gramme to a gramme compressed into small tablets and combusted in the bomb calorimeter.

As explained above it is found that the actual direct calorimetry as measured by the human calorimeter gives the same results as those from indirect calorimetry as measured by the bomb value of the food eaten minus the bomb value of the excreta produced from that food.

Such a method of estimating the Calorie output of a man takes much time and is very costly and cannot be used on any large scale. It certainly could not be used to ascertain the Calorie value of the diet of a family, an institution or the nation. There are two convenient methods of indirect calorimetry—one applied to the individual and one more useful in estimating the Calorie value of a diet. The first method needs rather expensive apparatus, such as the Benedict-Roth portable apparatus which can be used at the bedside, and the other no more than a book of tables, a balance and logarithm tables, slide-rule or a calculating machine.

The former method is chiefly adopted in hospital practice in measuring the Calorie output of a person's basal metabolism, i.e. the rate at which he is giving out heat some 12–16 hours after his last meal and when in a state of rest. The Benedict-Roth apparatus measures this in so short a time as 10–15 minutes by measuring the consumption of oxygen during that time. If we make the assumptions that the protein consumed during that time is negligible and that the carbohydrates and fats during that time are completely consumed to carbon dioxide and water we can estimate the heat given out from the oxygen absorbed and the carbon dioxide exhaled. The volume of carbon dioxide given out divided by the

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[1] For technical details, see TINKLER and MASTERS. (1932), *Applied Chemistry*, 2, 266-75. Crosby Lockwood & Son.

Indirect Calorimetry: by gaseous exchange

TABLE FOR CALCULATING CALORIE OUTPUT FROM OXYGEN ABSORBED

(After Zuntz and Schumberg, modified by Lusk)

Non-protein Respiratory Quotient.	Calories per Litre O_2.	Per cent. Calories derived from :	
		Carbohydrate.	Fat.
0·707	4·686	0·0	100
0·71	4·690	1·10	98·9
0·72	4·702	4·76	95·2
0·73	4·714	8·40	91·6
0·74	4·727	12·0	88·0
0·75	4·739	15·6	84·4
0·76	4·751	19·2	80·8
0·77	4·764	22·8	77·2
0·78	4·776	26·3	73·7
0·79	4·788	29·9	70·1
0·80	4·801	33·4	66·6
0·81	4·813	36·9	63·1
0·82	4·825	40·3	59·7
0·83	4·838	43·8	56·2
0·84	4·850	47·2	52·8
0·85	4·862	50·7	49·3
0·86	4·875	54·1	45·9
0·87	4·887	57·5	42·5
0·88	4·899	60·8	39·2
0·89	4·911	64·2	35·8
0·90	4·924	67·5	32·5
0·91	4·936	70·8	29·2
0·92	4·948	74·1	25·9
0·93	4·961	77·4	22·6
0·94	4·973	80·7	19·3
0·95	4·985	84·0	16·0
0·96	4·998	87·2	12·8
0·97	5·010	90·4	9·58
0·98	5·022	93·6	6·37
0·99	5·035	96·8	3·18
1·00	5·047	100·0	0·0

oxygen absorbed is called the respiratory quotient, and during the post-absorptive stage (i.e. 12–16 hours after a meal) is 0·82. From the Lusk table (p. 28) we see that every litre of oxygen absorbed should represent 4·825 Calories at a respiratory quotient of 0·82. Similar figures from the carbon dioxide evolved can be used.

Actually it is usual, following Benedict, to calculate the Calories from the oxygen absorbed, though Poulton, in this country, gave evidence that it is better to calculate it from the carbon dioxide evolved, on the grounds that all the oxygen absorbed does not reappear as carbon dioxide evolved. In hospital practice it is usual to accept absorption of oxygen as a sufficiently accurate measure of the Calories probably evolved. At any rate the measurement is accurate enough to aid the physician in diagnosis of such diseases as hyper- and hypothyroidism, leukæmia, and Addison's disease.

Similar methods of estimation can be extended to measuring the heat output in various occupations—sitting, standing, sewing, dressing, and undressing (20 to 60 per cent. increase) to rowing (1000 per cent. increase)—and have been very useful in fixing minimum rations for young recruits in the army. But again it is too cumbrous and expensive to be used in estimating the Calorie values of diets.

Indirect Calorimetry : by food intake. As was said above, the average calorie value of carbohydrates burnt in the body is assessed at 4·1 per gramme, that of fats 9·3, and that of proteins 4·1. Therefore from the analyses of foods we can calculate their Calorie value to the body. To take an example :

Suppose that we analyse a food and find that it consists of

Protein	5·0 per cent.
Fat	10·0 ,,
Carbohydrate	20·0 ,,

Water and mineral material to 100.

Then its Calorie value per 100 grammes would be

Protein . .	5·0 × 4·1 =	20·5
Fat . . .	10·0 × 9·3 =	93·0
Carbohydrate .	20·0 × 4·1 =	82·0
Total . .		195·5
or per oz. . .		1·955 × 28·36 = 55·44
or per lb. . .		1·955 × 453·6 = 886·8

For all practical purposes 196 per 100 grammes, 55·4 per oz. or 887 per lb. are sufficiently accurate values.

Tables of the composition and Caloric values of foods have fortunately been made out by various workers in different countries and the commonly used ones are here given :

The Chemical Composition of American Food Materials. Atwater & Bryant. Washington, D.C., U.S.A., 1906. 10 cents.

Analyses and Energy Values of Foods. Plimmer, H.M. Stationery Office, 1921. 6 shillings.

Nahrungsmitteltabelle. Schall, 10th edn. Kabitzsch, Leipsig, 1932.

Chemical Composition of Foods. Medical Research Council Special Report No. 235, 3rd impression. McCance and Widdowson. H.M.S.O. 1942. 3 shillings.

Nutritive Values of Wartime Foods. Medical Research Council War Memorandum No. 14. H.M.S.O. 1945. 1 shilling.

Excepting the last two sets of tables, those mentioned deal mainly with raw food as purchased, but those compiled by McCance and Widdowson contain also very many analyses of cooked foods, including made dishes. Moreover they give us a fairly exhaustive analysis of the " mineral " elements contained in the foods and do not lump them all together as " ash." A further advantage is that they give the available and unavailable carbohydrate in fruits and vegetables, instead of combining them, so that we know the amount of " roughage " these foods contain and also have a more accurate estimate of the Calories obtainable from the carbohydrate and the total Calories yielded by the food under consideration. Such tables are naturally to be preferred and probably will oust all others.

Given good analyses tables, it might seem an easy task to obtain the caloric and other intake of an individual, a family, a boarding school or other institution or the nation, and manifold attempts to secure such information have been and are being made, and the results accepted without reasonable criticism. It should be said at the outset that such results approximate only roughly to the truth, the approximation being closest when applied to the individual and least accurate when applied to a group of people of mixed ages and sexes.

(i) No food table can ever give the exact composition of the food actually eaten because the analyst rarely has time to collect samples from all different parts of the country and analyse them. At best he takes " 34 samples from different shops." He cannot, for example, analyse the egg eaten. Food tables give only the probable composition of the individual foods eaten.

(ii) Food tables compiled in this country do not apply to foods consumed in another. When American tables are compared with

British it is seen that there are wide differences. The herring caught around the coasts of Great Britain has 2½ times more oil than the American. On the whole British foods are moister than American with the one exception of jams. Each country should have its own analyses made.

(iii) When made dishes are eaten, it must not be assumed that the recipe used is that of the samples analysed by the analyst nor the time and nature of the cooking is the same. We all know how milk puddings can vary in consistency. The utmost which can be done to estimate the food value of a particular made dish (apart from sampling it then and there and analysing it) is to obtain the recipe from the cook, if she knows it, and assume that in cooking it loses the same amount of water as a similar dish analysed in the tables. (Personal communication from Miss M. W. Grant.)

Such are the difficulties which meet the scientific person at the outset. More will appear as the investigation proceeds.

There are three main methods of carrying out an investigation of food intake: the individual method, the housekeeping or store cupboard method and the budgetary method. Of these the individual method is to be preferred.

The ***individual method*** consists in weighing at table the food actually consumed at each meal every day for a week. It has been shown that the day is not a long enough period, but that a seven-day period gives a fairly accurate picture of the day's average intake. The weighing is best done by a laboratory trained worker. Scales accurate to (say) 2 grammes are advisable. Care must be taken to weigh back the waste, the inedible and the uneaten parts of the food, the unwanted and the inevitable losses due to the sticking of sauces, gravy, etc., to the plates, knives and forks. Where milk, sugar, butter and jam or marmalade are concerned it is worth while to keep a bottle of milk, a bowl of sugar, a pat of butter and a jar of preserve for the subject of the experiment and measure or weigh them at the beginning of a meal, or day, and the end.

If the weighings are carried out by a trained worker we may assume that the actual food taken in is correctly estimated, but not the actual food *needs*. Some people eat more and others less under observation. Children may show off by eating more than usual. The actual weighings make the meals abnormal. The observer may even unconsciously deter the subject from eating foods difficult to analyse. If, however, the experiment is carried out for a week with perhaps a day or two's trial runs immediately beforehand, the results can be taken as accurately representing the food normally taken during a period that of the experiment.

Nor should the results be much less reliable if an educated but untrained person conduct the observation. This is the method used in this country by McCance and Widdowson in their investigations of individual intakes, and the instructions they give to their investigators are here appended.[1, 2]

INSTRUCTIONS

1. Weigh each kind of food separately, just as it is served to you. If raw, say so. If you are eating any food such as fish or chops that contain bones or fruit with skin or stones, please say whether your weight included the waste.

e.g. Kipper, weighed with bones.
Orange, weighed without skin.

There is no need to weigh the *waste*, but please weigh any *food* you leave and deduct it from the food you first weighed out.

2. If you weigh anything on a plate do not forget to subtract the weight of the plate before entering the result on the form.

3. You need not bother to weigh eggs. Just count them and put the number. Sugar may be weighed, or measured in lumps or by the teaspoonful (say whether level or heaped).

4. Please say whether your bread is white or brown.

5. Do not forget to put down all sweets and chocolates under "Extras."

6. Please say whether your fruit was fresh, stewed, or tinned in syrup. For stewed and tinned fruit weigh the fruit and juice together.

7. Do not include gravy in the weight of the meat; measure the gravy separately in tablespoons. Please say what kind of meat or fish you eat.

8. It is a good plan to weigh out for yourself at the beginning of the week ¼ or ½ lb. of butter and always use from this piece. You need not then weigh the butter as you eat it, but simply put "¼ lb. of butter started" and "¼ lb. of butter finished," when it is so. If any of the butter weighed out to you remains at the end of the week, say what it weighs.

9. We are very anxious to know how much milk you drink per day and how you drink it, so please weigh the milk if possible or measure it in tablespoons. Say how much milk you drink alone, and how much you put in a cup of tea, cocoa, etc. Do not forget to put down how many lumps or teaspoonfuls of sugar you take in your drinks.

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[1] Widdowson, McCance and Widdowson. (1936), *J. Hygiene*, **36**, 269, 293.

[2] McCance, Widdowson and Verdon-Roe. (1938), *ibid.* **38**, 596.

This Indicates how to Enter the Results and is not meant to be a Plan of an Ideal Diet

Food.	Amount.	Weighed (Raw or Cooked).
Breakfast :		
Cornflakes	¾ oz.	—
Sugar	2 level teaspoons	
1 boiled egg	—	—
Bread (white)	2 oz.	Toasted
Butter started	4 oz.	—
Milk on cornflakes and in 2 cups of tea (no sugar taken in tea)	5 oz.	
Dinner :		
Irish Stew :		
Mutton weighed with bone	2 oz.	Cooked
Carrots	1¼ oz.	,,
Potatoes (boiled)	3¼ oz.	,,
Gravy	2 tablespoons	,,
Stewed plums weighed with stone	3 oz.	,,
Boiled custard (made with egg)	2 oz.	,,
Tea :		
Bread (white)	3½ oz.	—
Butter from ¼ lb.	—	—
Jam	1 oz.	—
Plain cake	2 oz.	—
2 chocolate biscuits (cigarette size)	½ oz.	—
Milk in 2 cups of tea	2 tablespoons	—
Supper :		
1 cup of cocoa :		
Cocoa	⅛ oz.	—
Milk	4 tablespoons	—
Sugar	1 teaspoon (level)	—
2 plain biscuits (digestive)	1 oz.	—
1 apple (weighed with skin and core)	3 oz.	Raw
Extras :		
Milk at school	⅓ pint	—
Boiled sweets	1 oz.	—

When working-class diets are being collected the task is more difficult and the accuracy of the results more debatable. A promise of co-operation must be obtained through welfare clinics, health visitors or medical officers of health. A visit is paid preliminarily to the investigation and the diet sheets and what is to be attempted explained. A further visit each day during the investigation is generally necessary to check errors and remove misunderstandings. The accuracies of the records must be estimated by the visitor and the data obtained rejected or accepted on that estimate. While the accuracy can never be that of a trained worker it is considered that data so obtained give some sort of picture, both qualitative and quantitative, of the diet habits of the person under observation.

One modification of the individual method used by officials of the Ministry of Food during the war of 1939–45, to investigate the food habits of munition workers, must be mentioned. They enquired from each worker who was willing to co-operate what and how much he had eaten at the various meals of the preceding day. If, for example, he said that at the morning break he had eaten a hunk of bread and a lump of cheese they got him to specify the size of each by choosing a particular sized piece of bread and of cheese to imitate what he had consumed. Such a method is very rough, but it is contended that it gives data of value—certainly of the type which a statistician can analyse. Experiments made upon University students suggest that estimates correlate well with actually measured intakes.

It should be clear that the individual method of estimating the Calorie and other intake of the subject of the experiment gives a moderately accurate picture of what a person consumes and, if the experiment continues long enough, of his actual needs. Naturally the most accurate estimates are those made under an approximation to laboratory conditions by trained workers. It is probable that we may have to revise many of the estimates of the daily needs of people for Calories, proteins, mineral elements and vitamins when sufficient data have been collected, for it is an unfortunate fact that by no means sufficient individual data, despite all the efforts made from the time of Voit and Lyon Playfair down to to-day, have been collected and analysed. We need individual data by the hundred, if not the thousand, made in each country and walk of life, by workers using identical methods of collection.

Before proceeding to discuss the group methods of collection of data it would be well to consider the tables and what information they can yield. It might be thought that once the data are collected all the investigator has to do is to turn to the tables and by some tedious arithmetic[1] calculate the approximate values of the foods eaten. This is not so. In the first place the introduction to the sets of data made by the compilers should be read and thoroughly understood. Too often they are skipped, or if read, forgotten, with the result that tables are used to support contentions they could never support.

In some of the analyses we meet the terms "as purchased" and "edible portion." The terms are almost self-explanatory, but confusion often arises in the minds of students and lay folk and even in the minds of well-recognized exponents of dietetics.

Foods "*as purchased*" often have portions which have to be removed or are discarded before the food is eaten. Good examples are the skin and bones of fish, the bones and gristle of meat, the shells of eggs and nuts, and the peel and core or stones of fruit. The "*edible portion*" will then be a fraction only of the food as purchased. The fraction will be high in some foods and lower in others. In bread, biscuits, butter, and cakes it will be 100 per cent. "Edible portion" will equal "as purchased." In cheese, with its rind, it will be a little less. With many meats it is about 83 per cent.; with fish, particularly small and flat fish, much less —e.g. 40 per cent. With fruits we may have 100 per cent. (blackberries) down to 40 (melons); and in walnuts it sinks to the low figure of 26.

One pound of food as purchased will therefore have a lower Calorie value than one pound of the edible portion of the same food. In one pound of food as purchased there will probably be less than a pound of edible material and the Calorie value of this will be lower than the corresponding Calorie value of a pound of edible portion. When estimating the Calorie value of a diet this distinction has to be borne in mind. If it be an individual diet which is being investigated the weighing of foods will be carried out at table and it will be the edible portions either cooked or ready to serve which will be weighed, except perhaps when flat fish and herrings or fruits are taken. Even then the waste can be weighed and the edible portion estimated. When the diet is that of a family or institution it will probably be the weights of foods *as purchased* which will be estimated. The item which will have greatest influence on the total will be the meat, for the other items which supply the bulk of the Calories—bread, butter, milk, and sugar—should have no waste.

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[1] We certainly recommend the abandonment of arithmetic for the slide rule with its automatic approximations. Food values cannot possibly be accurate to more than the second significant figure. Still more time-saving than the slide rule is the calculating machine, a portable form of which is on the market. Anyone can learn to use such machines with skill, speed and accuracy in a few days. Their only disadvantage is that they encourage the user to state results with a supposed accuracy to the eighth significant figure!

Unfortunately the edible portion is not wholly consumed. It is inevitable that some should stick to the plate and to knives and forks. The fat of meat is often discarded; unpleasant-looking portions are dissected away (e.g. veins); burnt and underdone portions put aside.

This table wastage is an individual affair. It is lowest among the poorest [1] and during times of scarcity.[2] It depends upon training and is greater in one country than another. Institutional feeding apparently leads to great wastage, though training may keep the table wastage as low as 1 per cent.[2] It may rise much higher [3] and in institutions known to us it has risen over 10 per cent. In estimating an individual's diet, when the food is weighed at table it is quite possible to allow for table wastage, but in calculating the value of the diet of a family or institution this is by no means easy. There are losses due to carelessness in preparing the food. One person will pare away much more of a potato than another. One cook will utilize much less of the fat that cooks out of a joint than another. Sauces, even "pouring sauces," will not wholly leave the saucepan for the sauce-boat or the sauce-boat for the plate. Consequently we can give only an approximate figure for the food consumed by a group of people—an outside figure. It is usually thought that the actual amount consumed is as much as 10 per cent. below this outside figure, and that allowance is commonly made. It ought, in a well-regulated family or institution, to be considerably less.

Edible portion minus kitchen and table wastage we may term "input." [4] This "input" food is never wholly digested and absorbed by the alimentary tract. There are indigestible fibres in plant and animal foods which are not only unabsorbable by the alimentary mucous membrane but also prevent the absorption of otherwise absorbable products of digestion. By hurrying food along the small intestine they may impede complete absorption. Sometimes as much as 20 per cent. of a food material is lost to the body owing to incomplete absorption.[5] Moreover the alimentary tract and its secretory glands may have to pour out more digestive juices and lubricating material on some foods than others. The net gain to the body (which alone concerns us) will be greater when there is less outpouring of digestive juices.

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[1] CATHCART and MURRAY. (1931), *Med. Res. Council Spec. Rep.*, No. 151.

[2] FRIEND. (1935), *The Schoolboy*, Heffer & Sons Ltd.

[3] GEPHART. (1917), *Boston Medical and Surgical Journal*, 176, 17.

[4] We have borrowed this term from wireless telegraphy as a convenient if ugly word.

[5] See below, p. 145, under "Availability".

Estimates have been given of the loss of Calories through non-absorption of various foods and in mixed diets. The following figures are given :

	Per Cent.
Rice	2·6
Milk	4·4
Bread	4·5
Meat	5·5
Potatoes	6·8
Carrots	20·2

(Rubner)

For the mixed diets we can calculate that 4 per cent., 7 per cent., and 11 per cent., respectively, of the "input" Calories are lost through defective absorption in the following diets : (i) Diet containing much animal food, (ii) diet containing a moderate amount of animal material, (iii) diet containing little animal material.[1]

"Input" Calories minus loss through defective absorption we may term "Intake" Calories. By the principle of the conservation of energy "intake" Calories must, eventually, and when the body is in equilibrium, equal "output" Calories, i.e. the Calories as measured by the calorimeter.

We have therefore a means of estimating roughly the Calorie output, or the Calorie needs of a person or group of persons, by collecting data of their food consumption and calculating the Calorie value of the foods eaten from analysis tables. The method involves but a little arithmetic and intelligence and is far easier than the more scientific and direct methods of estimation by human Calorimetry or via gas analysis. Its results, however, must not be unreservedly accepted.

We may sum up the relations of the figures as given in the analysis tables to the actual output of energy by the subject of experiment, thus :

As purchased (usually abbreviated to A.P.) minus waste (bones, peel, core, etc.) = Edible Portion.
Edible portion (usually abbreviated to E.P.) minus table waste = Input.
Input minus unabsorbed or secreted material = Intake.
Intake must equal Output, when the body is in equilibrium.

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[1] Wait. *U.S. Dept. of Agriculture.* Bull. 53.

The relation of these values to one another is a variable one. We have seen that the relation E.P. to A.P. may be 1 : 1 (bread, milk, butter), or it may be as low as 1 : 3 (nuts). We cannot give any average figures and it is absurd to pretend to do so. The tables give the relation when wanted. In calculating the Calorie value of a diet we have merely to be careful to see which set of figures is appropriate.

How much is wasted at table is a variable quantity depending largely upon training, and the loss due to incomplete absorption plus secretion of digestive juices varies from 4 to 10 per cent. or more, depending upon the nature of the diet. It is a convention to assume that the two together approximate to 10 per cent.

If this be true, the Calorie value of the edible portion of food minus 10 per cent. will equal the Calorie value of the intake, and this in turn the output of Calories by the body. Ordinarily we do not concern ourselves so much with the output of Calories by the body but by the more easily estimated Calorie value of the food bought. We speak of the Calorie value of a diet, meaning by that the Calorie value of the food eaten without making any allowance for unavoidable waste on plate or in the alimentary tract. This is in fact the Calorie value of the edible portion.

Group Dietaries. Often we wish to know the average value of the diets of a group of people, whether of the family, institution or a nation. This presents no real difficulty except in interpreting the results.

The Housekeeping Method. If the family is the unit,[1] the food in the house at the beginning of the period of investigation (usually a week at least) is estimated and allowance is made for that at the end of the period. All food bought during the time is weighed and so is the waste. The food consumed equals that of each commodity at the beginning plus that bought during the period minus that at the end and minus the waste. Usually in such an investigation the wastage of each food (crusts of bread, etc.) can be ascertained and we can obtain a fair measure of the Calorie, protein, fat, carbohydrate, mineral elements, and vitamin content of the whole diet and therefore the input of the family.

Much the same methods will be used in an institution, e.g. a boys' school. The accounting department of the institution can supply the data for the food entering the institution in a definite period, and, assuming no leakage, this gives over a period such as a month or a term the gross consumption of food. From this must be subtracted the wastage which may be itemized if the accounting department is efficient. It may be waste bread; waste fat (either sold to soap merchants or converted on the premises into soap); or garbage which goes to the pigsties. If the amounts of the two former are known their dietary value can be directly assessed, but if all waste goes into the garbage an analysis of mixed samples is essential for accurate evaluation of the loss. Usually all the wastage goes to the pigs and it is difficult to make an allowance for it except in vague approximations. Where the waste is small this does not much matter. For example, fairly careful estimates of the nature of the waste at Christ's Hospital [1] suggest that it accounts for, on the average, but 0·7 per cent. of the total gross Calorie value of the food. In other institutions the table wastage may be much greater, e.g. St. Paul's School, Concord, U.S.A.,[2] where it was in the Upper School 22 per cent. in the protein, 23 in the fat and 7 in the carbohydrates. In public schools in this country the weight of the table wastage is often some 10 per cent. of the food served, though in a vegetarian house of a school investigated by one of us, where there was very little cooked food served, the waste was practically negligible. (Clearly much can be done to cut down the wastage and caterers should consider a high wastage a sign of bad catering and bad training of the recipients of the food.)

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[1] CATHCART and MURRAY. (1931), *Med. Res. Council Spec. Rep. Series.* (1931), No. 151 and 1932, *ibid.* No. 165.

The net Calories, after subtraction of the Calorie value of the waste, divided by the number of people fed and the number of days in the period of estimation, gives the average Calorie intake per person per day.

This method gives a satisfactory and understandable result if all the people under consideration *are of the same age and sex.* This is rarely the case except in some institutions such as the army and some public schools where all can be counted as adults. Usually women and children are included. For example, in a preparatory school there may be children from about 6 years of age to 14, maids, matrons, and masters all fed from the same stores and kitchen. In a public school there will almost invariably be kitchen staff, infirmary staff, and housekeeping staff to complicate the Calorie issue. In a co-educational school the complication is still greater.

There has been a conventional method of obviating the difficulties involved by these complications. It is known that on the average a man eats more than a woman, and both more than a child, say, of five. It is also known that their Calorie output varies in a similar way. So dietitians in the past have composed scales of values purporting to represent the Calorie needs of children at each age and of women expressed as fractions of the need of an adult male. The needs of the adult male in sedentary occupation are taken as unity. He has a " man value " of 1·00, while the adult female is given another value (e.g. 0·83 or 0·7 according to whose scale you adopt) which is her " man value," " index " or " coefficient." Children are given coefficients according to their age, e.g. at 3 years of age the coefficient given may be 0·5—the " man value " of this child is half that of his father, and so on. Of such scales there were in 1936 no less than thirty-eight [1] and they have received additions and complications since.

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[1] FRIEND. (1935), *The Schoolboy.* Heffer & Sons Ltd.

[2] GEPHART. (1917), *Boston Medical and Surgical Journal,* 176, 17.

Such scales have been used in this way: Suppose we wish to assess the Calorie needs of a family consisting of a father (say a lawyer), his wife, son of 14, daughter of 10, and two domestics, and we adopt the Cathcart and Murray scale.

Father = 1·00
Wife = 0·83
Son of 14 = 1.00
Daughter of 10 = 0·80
2 maids = 1·66

Total 5·29

One " man " = 3000 Calories. Therefore the total Calorie needs is 5·29 × 3000 = 15,870 or (say) 16,000 per day.

A boarding school or other institution can be reckoned in the same way.

200 boys all 14 or over [2] = 200 × 1·00 " men " = 200·00
10 male teaching staff = 10 × 1·00 = 10·00
5 female " " = 5 × 0·83 = 4·15
5 male non-teaching staff = 5 × 1·00 = 5·00
10 female " " = 10 × 0·83 = 8·30

Total 227·45

∴ Daily Calorie needs = 227·45 × 3000 = 682,350 or say 700,000 Calories.

This method of calculation seems to us to have no advantage whatever over saying that a man's needs are 3000 per day, a boy of 14's 3000, an adult woman's 2500, a girl of 10's 2400 and adding these figures. But perhaps the method is held to be of value when different occupations are to be taken into account.

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[1] WIDDOWSON. (1936), *Journ. Hygiene*, **36**, 269.

[2] All later scales quite rightly give a much higher assessment for adolescent boys.

It is known that *on the average* the needs of an agricultural labourer are more than those of a professional man. The agricultural labourer's "man value" is often taken at 1·3. Suppose that among the male non-teaching staff of the school considered there is a gardener. Then we should have to separate out this staff into 4 × 1·00 and 1 × 1.30 and make their "man value" 5·3 instead of 5·00. We cannot see any particular gain in this method of computation.

In former editions of this book we have given a few of the more popular of the tables used, and anyone interested in them may find them there. We have come to the conclusion that the index should be discarded because (i) it tells us nothing new, (ii) it hardly shortens any calculation, (iii) it applies only to Calories, but there is a danger that it may be applied to first-class protein, calcium,[1] iron and vitamin intakes and even the cost of living. It is a waste of time and energy to have an index, or man value, for each of the essential principles of diet, (iv) it is based on an assumption or set of assumptions which bear little relation to fact—of which see later, and (v) it makes dietetics appear more "scientific" than it is.

Scales of Calorie values based on "man values" are distinctly suspicious commodities. This is unfortunate, for that suspicion corrodes the value of all the work done on group diets from the Great War until the publication of Sir John Orr's book *Food, Health and Income*, 1937. We have to take them "for what they are worth," and their worth depends upon values largely subjective. It is regrettable that the family or group diet should be investigated via the individual diets of each member of the group. This will receive further confirmation when we study factors of diet other than Calories.

Despite these considerations, it is essential for practical purposes that some yardstick should be adopted. A standard may be wrong and unscientific, but it is better than none at all. All standards in dietetics are based to a great extent upon guess-work influenced by personal predilections, and are therefore open to suspicion. But it must be remembered that the guess-work is that of intelligent scientific men trained in dietetics and therefore more likely to be near the truth than the guess-work of the layman. The guesses we are choosing to hold up for inspection and use are those of the National Research Council of the United States. After all, the science of dietetics has flourished much longer and more fully in

[1] One well-known dietitian fell into the error of applying the index to calcium needs. The Calorie "index" for a child of 3 may be 0·5 but its calcium index may be 1·25 and its cost of living index 0·75.

the United States than in any other country, and that Council is more likely to be nearer the truth than one in any other country. Although we think it satisfactory this is a personal impression only.

Here it is for Calories:

Man (70 kilos or 11 stone)		Children, 1–3	1200
Sedentary	2500	4–6	1600
Moderately active	3000	7–9	2000
Very active	4000	10–12	2500
Woman (56 kilos or 8 stone 11 lb.)		Girls, 13–15	2800
Sedentary	2100	16–20	2400
Moderately active	2500	Boys, 13–15	3200
Very active	3000	16–18	3800

The way to use this table is not to apply it in any hard and fast way. It represents average values only. If a group of people on the average are taking Calories equal to the American recommendations, or even 10 per cent. less, their diet may be considered satisfactory, so far as the Calories are concerned. This is not true, as we shall see, for individuals. One may be taking 30 per cent. below the recommended figure and yet be overfed, and another 50 per cent. more without taking too much. That, at least, is the deduction we make from individual Calorie intakes dealt with in more detail below.

Group Dietaries Continued. The Budgetary Method is used more to ascertain whether the income of a family is sufficient to give it a satisfactory diet rather than to discover whether it actually does. The investigator has to estimate the family income and all the necessary outgoings for rent, insurance, clothing, light, fuel, burial clubs, etc., and see if the balance left after such necessary expenditure is sufficient to purchase an adequate diet. It is quite possible, despite contentions to the opposite from old-fashioned civil servants, to assess the minimal cost of a satisfactory diet in any town at any particular time, given market prices at that time. It has been usual in social science investigations in this country to utilize the British Medical Association figures published as long ago as 1933 and multiply them by some factor to represent the rise in the cost of living. But we must protest against this, for though the British Medical Association Committee which produced these figures showed that it is possible to assess the cost of a satisfactory diet at any time and any place, given the market prices, it is not wise to accept their figures to-day, because our conception of what is a satisfactory diet has changed in the intervening years. The British Medical Association figures are almost pre-vitamin figures, for example. The figures should be calculated afresh for each investigation for the time and place of the investigation and by a dietitian resident in, or at least conversant with the social conditions of, that locality.

Such investigations are useful in assessing the needs of people receiving public assistance. For example, supposing the breadwinner of a family is incapacitated by tuberculosis and removed to a sanatorium, what public assistance should be given to the family while he is recovering ? It is clearly absurd to give so little that after the necessary overhead charges are met there is not enough left for adequate food. That would push the other members of the family down the slope towards tuberculosis. It is absurd, too, to fix the rents in a new housing area so high that families living in them have too little to spend on food. Morbidity rates on a new estate have been shown to be higher than in the slum property from which the families have moved and the probability is that the increased rent reduced the available balance for food. Local authorities need the help and advice of the dietitian in many of their undertakings.

The budgetary method has also produced much evidence in favour of family allowances. Investigations in Merseyside, Bristol, Birmingham, Southampton, to mention a few areas, have shown that malnutrition is due to poverty and a main cause of poverty is having a large family.[1] Where the family is large it may actually be the case that the money available for food after rent, light and fuel and clothing and insurance are accounted for is not sufficient to buy an adequate amount of Calories.

Which method of investigation of a diet should be adopted must depend upon circumstance. The individual method is the most accurate, but it has its drawbacks when the diet of an institution is investigated over a period of time. The subjects of the investigation may leave the institution, and a false picture of the change introduced by a change of management be given, even if the greatest care to choose comparable individuals be taken. The housekeeping method will be naturally preferred in dealing with an institution or a family if the bookkeeping in that group is accurate and reliable. The budgetary method will be used by schools of social science where rapidity and rough results are all that are necessary. The investigator, as the pupils of one of us have found, must adapt methods to the investigation in hand.

Basal Metabolism. We have so far been discussing the heat given out by the body in ordinary conditions of life, and have given more than a hint, which will be justified later, that there is as yet no fixed quantum of heat output, which we can say is "correct" for any individual. We have indicated that in the normal person who is neither gaining weight nor losing it—who in other words is in equilibrium—the output of Calories exactly equals the intake of potential Calories in the food assimilated. And we have given an account of means by which the output of Calories can be measured and the putative intake of Calories can be measured from the input.

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[1] Among illustrations of this fact may be quoted a paper by YUDKIN (1944), *Lancet*, **2**, 284, showing that, among pupils of schools in Cambridge, the larger the family the smaller is the growth rate, the lower the hæmoglobin and force of hand grip.

We naturally ask, is there anything fixed and constant in the energy output of an individual, from which we can build up a quantitative science of dietetics? Does the human being never behave like a machine in which so much fuel burnt produces so much energy? The answer is that Basal Metabolism provides the indication that it does.

What happens to the body when there is (i) an insufficient input, and (ii) no input at all (i.e. starvation)? In both cases the body is forced to consume its own muscles or its fat and carbohydrate depots to meet the inevitable demands for energy. Whenever the body receives less Calories than it gives out there is a loss of weight and we utilize this fact when we are wanting to get rid of an excess of body weight. The matter will be discussed in a later chapter under the treatment of obesity. What concerns us now is basal metabolism, i.e. the inevitable loss of heat from the living body when at rest, and its relation to total metabolism in order to see if we can give any theoretical figure for the output of Calories per day.

The animal body, unlike the non-living machine, needs food for its maintenance and repair, even when at rest. The body never is at rest completely, even when in a state of extreme quiescence. The heart pumps blood against pressure through arteries and capillaries. The chest muscles do mechanical work in respiration. Probably even the muscle tone of the striped muscles consumes energy which needs replacing. Energy is needed for the secretion of fluids by the body, e.g. saliva, sweat, and urine, and also for some of the chemical transformations which occur in the body. There is therefore a loss of energy from the body at rest and this loss is expressed as a loss of heat.

This inevitable production of heat when at rest is the base-line, the jumping-off ground, of metabolism. It is presumably its irreducible minimum. A whole literature has grown up round the study of this irreducible minimum which is termed "basal metabolism." For the human being the basal metabolism is taken to be the output measured in Calories of the body in a state of complete rest some twelve hours after the last meal. The time most convenient for the estimation is in the morning after the night's sleep. The subject of the experiment is placed in a Calorimeter and his heat output measured over a period of one to two hours. The daily basal metabolism is calculated from the result obtained. Experiments upon animals (swine) suggest that the body does not reach its basal output quite so soon as twelve hours after the last meal, but the results are sufficiently near the basal value to be of great practical use. For details of the methods of estimation of the basal metabolism, readers are referred to the original treatises on the subject.[1] What we have to consider now is the influence upon basal metabolism of such factors as height, weight, and skin area, of age and sex and of the endocrine organs.

Influence of Height, Weight and Skin Area upon Basal Metabolism. Arguments from first principles suggest that the shape and composition of the body will influence its metabolism, and that surface is of paramount importance. The larger the surface of the body relative to its bulk, the greater is the amount of heat lost by radiation. A reference to the accompanying diagram (Fig. 2) will make this clear.

Let us suppose that we have two bodies, the first being 9 feet high, 3 feet broad, and 1 foot thick, and the second measuring 3 feet in every dimension. Both will have a content of 27 cubic feet, but the first will have a surface of 78 square feet, the second of only 54 square feet; in other words, the surface exposed is almost one-third greater in the one case than in the other. If heat is lost at a rate comparable with the area, the amount of heat lost will also be proportionately greater. The first of these figures would represent the condition of a tall, thin man, the second that of a short, stout man; and as the former must lose about one-third more heat than the latter, his basal metabolism will be one-third higher than the latter's. That this is borne out in fact is

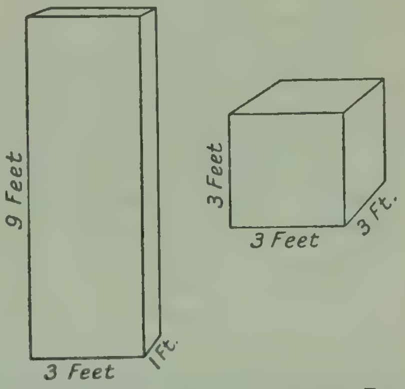

Fig. 2.—To Illustrate the Influence of Shape on Area of Surface

the opinion of such physiologists as Rubner, Graham Lusk and Du Bois, who appear to have made out an excellent case for their contention. When we find that if we are careful to measure the area of animals so different as dogs, horses, mice and men, the output of Calories per square metre is approximately 1000 per day, we may be sure that we have reached something fundamental even if we cannot pretend that we have the whole explanation.[1]

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[1] Du Bois. (1936), *Basal Metabolism in Health and Disease.* Baillière, Tindall & Cox. See also Adams and Poulton. (1932), *Jour. Physiol.*, 77, Proc. i.

None the less, there is a school which still prefers to relate the basal metabolism to weight instead of area, and it is usual to calculate (say) the protein requirements of a diabetic in reference to his weight rather than to his area. Of course the heavier the body—i.e. the greater the number of cells which it contains—the greater is the output of energy, for each cell yields its quota. But this is true as a general statement only, for the kind of cell must also be considered. The energy outputs of a pound of bone, a pound of fat cells, and a pound of muscle cells must be very different. Fat and bone have a low rate of metabolism. Their activity and therefore their heat output is small. Muscle, on the other hand, is a very active tissue, and the same may be said of many of the glands. On this argument the man with heavy bones or much adipose tissue should have a basal metabolism smaller per pound than the thin and wiry individual. Those who take this position must maintain that it is the mass of active cells in the body which determines the basal metabolism.

To these it may reasonably be answered that as we have no conceivable way of measuring the mass of active cells in the body, the consideration does not help us in any but a negative way and that as the assumption that basal metabolism varies with area has a large mass of *data* to back it, it is as well to adopt that assumption. Moreover, any ordinary estimate of area of the body includes factors representing height or weight ; [2, 3] consequently when we calculate basal metabolism in relation to area we are at the same time relating it to height or weight. The formulæ for calculating skin areas have been shown to have a reliability of about 5 to 10 per cent. even in extreme cases, and the Calorie value per square metre based on those formulæ are fairly constant from individual to individual and even from race to race and species to species.

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[1] Physicists may be tempted to explain the area effect as an illustration of Newton's law of cooling in which the rate of loss of heat varies directly with the area of the body and the difference between its temperature and the temperature of the surroundings. That this does not apply to man is clear from the fact that the basal metabolism does not fall to zero when the temperature of the atmosphere rises to, or above, body temperature—indeed, it falls but very little, being much the same in Java as in Holland.

[2] MEEH. $S = K \times \sqrt[3]{W^2}$. K is a constant $= 0{\cdot}12312$.
DU BOIS. $S = W^{0{\cdot}425} \times H^{0{\cdot}725} \times 0{\cdot}007184$.

[3] See tables and curves for calculating areas from data of height and weight in DU BOIS' *Studies in Basal Metabolism*, or in M. S. ROSE'S *Foundations of Nutrition*. The nomogram on p. 48 gives a ready means of estimating surface area and the value of Basal Metabolism.

The figure for an adult male is approximately 40 Calories per square metre per hour (960 per 24 hours), or taking the area of an average male as 1·75 square metres this represents a basal metabolism of

$$40 \times 1{\cdot}75 \times 24 = 1680 \text{ Calories per day.}$$

Influence of Sex and Age upon Basal Metabolism. As might be expected, the basal metabolism of the adult female[1] is lower, viz. 37 Calories per square metre or 1350 Calories per day for a woman of 1·5 square metres area.

Once an individual has reached adult age the figure remains very nearly constant. It does, however, fall gradually, till in old age it has decreased to 90 per cent. of its former value. This is true of both women and men.

On the other hand, the basal metabolism of infants, children and adolescents shows a very different picture. It starts at about 30 and rapidly rises till at 6 years it reaches a peak of 60 Calories per square metre—a rate 50 per cent. greater than that of the adult. Thence it falls fairly rapidly at first and then more slowly till it reaches the adult figure of 40. According to Du Bois, there is a second peak at or about the age of puberty when the Calorie figure rises to 50.

In general we see that the vigorously-growing tissues of the young have a much more active metabolism than the mature tissues of an adult, even though the body is resting and fasting. This accords with the fact that the food requirements of the young have no direct relation to age or to weight. That there should be a rise in the basal metabolism in adolescence is not unexpected. It is a period of rapid growth in the first place and in the second there is the stimulating effect upon metabolism of endocrine organs, particularly thyroid and pituitary. So far as experiment has gone, this pubertal rise has not been observed in animals. A nomograph for finding the

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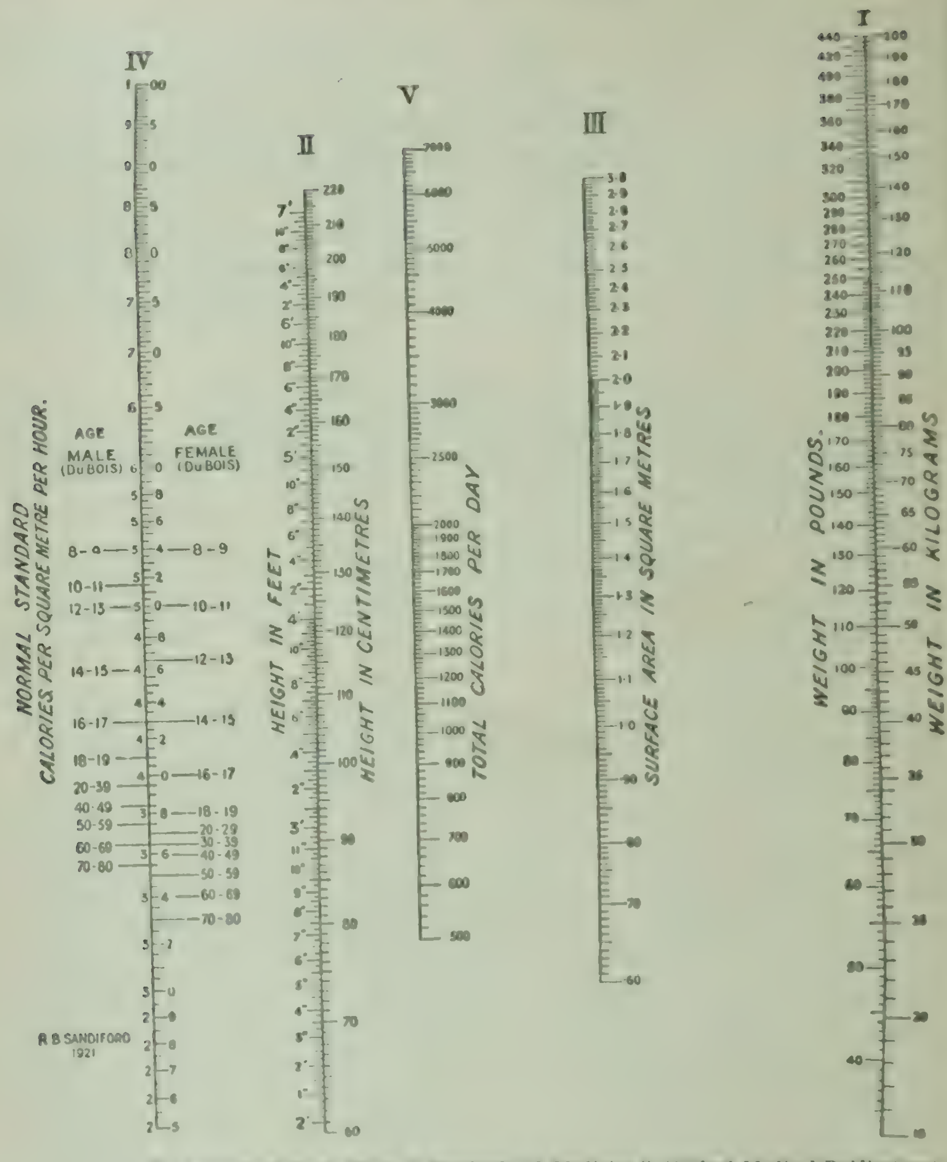
[1] Is there any fundamental reason why female protoplasm with its XX chromosomes should have a different efficiency from that of male protoplasm with XY chromosomes ? From anatomical investigations and data of athletic prowess it seems that there is. It would be interesting to have calorimetric data of androgynes, of bisexual pigs, of freemartins and intersexual birds and investigations of the oxygen intake of slices of tissues under the influence of œstrone and testosterone respectively.



By permission from Price, "Textbook of Medicine" (Oxford Medical Publications)

Fig. 3.—Boothby and Sandiford's Nomograph

The weight in pounds or kilogrammes is shown on Scale I. The height in inches and centimetres is shown on Scale II. The surface area in square metres is shown on Scale III. The normal standard calories per square metre of body surface per hour are shown on Scale IV. The total calories per diem are shown on Scale V.

Directions. Keep the chart flat. Use a flexible ruler with a straight edge, or a strip of stiff paper such as a postcard. (A) Locate the position of the weight and height on Scales I and II respectively. Apply the straight edge of the ruler and note where it cuts Scale III. Read the figure on Scale III, which will give the surface area of the body in square metres. (B) Locate the surface area on Scale III, and the normal standard Calories per square metre per hour for the age and sex of the subject on Scale IV. Apply the straight edge of the ruler, and see where it cuts Scale V. Read this figure, which gives the total basal calories per 24 hours.

Large scale nomographs may be obtained from W. B. Saunders Co., West Washington Square, Philadelphia, U.S.A., or from H. N. Elmer, 1641 Monadnock Buildings, Chicago, U.S.A.

normal basal metabolism of a person of given sex, height, weight, and age is given in Fig. 3.

Other Factors influencing Basal Metabolism. That the relation between area and basal metabolism is not quite so constant as has been suggested above is shown by the fact that the *previous history* of the person or animal under experiment does have some influence upon the basal metabolism.[1] A period of under-nutrition lowers the basal metabolism [2]; a period of heavy exercise raises it. A holiday in the country raised the basal metabolism of the experimental animals of the Russell Sage Institute, though it soon returned to the normal in the surroundings of New York. Doubtless this is true of man. Sleep, if deep, results in a lowering of the basal metabolism by some 5 or 6 per cent.

The influence of such a gland as the thyroid is great. Of all the endocrine organs it is the one which has greatest influence on metabolism. In cretinous and myxœdematous patients this falls 10, 20 and even 40 per cent. below the normal, and in hyperthyroidal persons it may rise to even 100 per cent. above the normal. So marked is the influence of the thyroid that the measurement of basal metabolism is used in diagnosing thyroid disease and the effect of treatment upon that gland. The pituitary anterior lobe and the suprarenal also have great influence upon the basal metabolic rate.

To sum up this section upon basal metabolism, i.e. the metabolism of the body in a state of rest 12 or more hours after food intake, we may say that—

(1) It is approximately constant for the individual.

(2) It is constant per square metre body surface for men and animals.

(3) The figure per square metre per hour is 40 for the adult male and 37 for the adult female.

(4) The figure falls somewhat with advancing age.

(5) In children it rises to 60 at the age of six with a second peak of 50 in adolescence.[3]

(6) Previous history has some influence upon it.

(7) Pathological conditions of the body, particularly thyroid, pituitary, suprarenal (cortex and medulla) disorders and fever, influence it very markedly.

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[1] See Du Bois, *op. cit.*, 160.

[2] See Wishart. (1934), *Journ. Physiol.*, **82**, 189.

[3] Nitschke and Schneider (1932), (*Zeit. f. Kinderheil*, **50**, 1) find an average deficit in rachitic infants of 17·5 per cent. Giving a vitamin D concentrate raises the basal metabolism in these infants but not in normal infants.

Basal Metabolism and Total Metabolism

That total metabolism, i.e. the total energy output of the day on full diet, bears some relation to basal metabolism, hardly needs stating. Total metabolism includes the work done in carrying one's body about and so varies with the *weight* of the body. Basal metabolism varies with the *area* of the body which has a mathematical relation to the height and weight. Consequently, total metabolism is influenced by basal metabolism. Clearly the ***physical work*** undertaken immensely influences the total metabolism. Heavy physical work entails an output of energy which must be made good, either by the consumption of food or of the tissues of the body. Therefore an increase of physical work entails an increased consumption of food.

Calories Required for Basal Needs of the Body and Waste in the Excreta (after Holt).

Age.	Basal Needs.	Wasted in Excreta.	Growth.	Activity.	Total.
1 year . .	500	150	200	150	1000
2 years . .	650	150	200	150	1150
3 ,, . .	700	150	200	200	1250
4 ,, . .	750	150	200	250	1350
5 ,, . .	800	150	200	300	1450
6 ,, . .	800	150	200	400	1550
7 ,, . .	850	150	200	520	1720
8 ,, . .	920	200	200	630	1950
9 ,, . .	1020	200	200	680	2100
10 ,, . .	1080	200	200	740	2220
11 ,, . .	1100	250	220	880	2450
12 ,, . .	1100	300	280	1020	2700
13 ,, . .	1180	320	280	1220	3000
14 ,, . .	1300	350	400	1350	3400
15 ,, . .	1400	400	600	1400	3800
16 ,, . .	1500	380	420	1680	3980
17 ,, . .	1550	300	250	1720	3820
18 ,, . .	1550	300	100	1630	3580
19 ,, . .	1550	300	—	1580	3430
20 ,, . .	1600	350	—	1300	3250

There are thus three sources of the energy output per day, viz.:

1. The basal metabolism.
2. The energy output due to being up and about.
3. The energy output due to mechanical work.

Perhaps we ought to add to these for the sake of completeness:

4. The loss of heat in the excreta.

5. The endothermic loss in the growing young due to growth (Holt). We give a table (p. 50) due to him which purports to show the relations of these quantities in the young. The sources of energy output due to being up and about, and to mechanical work, are combined as "activity."

The basal needs we have already considered. The "up and about" needs depend directly upon the basal metabolism and can be put at about 33 per cent. higher. The third theoretically depends only upon the mechanical work done, although in this we have to consider training and temperament of the person under consideration. If we consider the training perfect and ignore the temperament and loss in excreta, the sum-total, it is tempting to argue, should work out somewhat as follows, assuming 8 hours' "up and about," and 8 hours' mechanical work:

8 hours' sleep at a basal metabolism of 1680 Calories	= 560 Calories.
8 hours "up and about" at a rate of 33 per cent. higher	= 747 ,,
8 hours' work at 940 Calories plus metabolism at the "up and about figure"	= 1687 ,,
Total	= 2994 or

about 3000 Calories per day.

The third item needs some explanation. It has been estimated that a moderate amount of muscular work represents 100,000 kilogramme-metres (324 foot-tons) for one day.[1] The heat equivalent of this is 235 Calories. Now no machine using fuel can transform all the energy of oxidation of that fuel into work. In fact the efficiency of the most perfect machine working at ordinary temperatures cannot rise above about one-third, i.e. it transforms only one-third of the heat energy used into mechanical work and wastes the remaining two-thirds. Most engines are very much more wasteful than this, e.g. the efficiency of the steam engine is about 10 per cent. only. If we make the assumption that the efficiency of the body is at the high level of one quarter, the performance of mechanical work in 8 hours equivalent to 235 Calories entails an expenditure of $235 \times 4 = 940$ Calories.[2] To this we must add the

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[1] A measurement of the work done by a long-distance cyclist during 8 hours' pedalling on an ergometer gave the result of 370,000 kilogramme-metres. WISHART. (1934), *Journ. Physiol.*, **82**, 189.

[2] In experiments upon trained cyclists pedalling against known brake resistances in a calorimeter, Benedict and Cathcart showed that every extra Calorie of work needed 3·343 extra Calories of energy—an efficiency of nearly 30 per cent. Quoted in *Med. Res. Council Spec. Rep.* (1918), No. 13.

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energy output of the basal metabolism and for 8 hours being "up and about" = 747. Therefore, while doing mechanical work equivalent to 235 Calories the body must expend

$$940 + 747 = 1687,$$

which accounts for the third item in our sum.

This figure of 3000 Calories represents the theoretical daily output of a man doing eight hours' moderate physical work per day and corresponds with considerable nicety with the average intake as discovered in numerous investigations. If we add 10 per cent. to account for the loss in digestion and utilization of food, we see that the edible portion of the food should represent approximately 3300 Calories.

It is indeed tempting to measure the Calorie output by means of gaseous exchange of people engaged in various avocations and activities, to add up throughout the day the Calorie output during these activities, and then to state that the food requirements for such and such people should yield Calories to that total plus 10 per cent. to allow for inevitable losses.

Thus, sitting at rest has been measured to need 30 extra Calories per hour; dressing and undressing, 50 Calories; running, 500; swimming, 550; playing the piano, 55; or in the case of playing Liszt's music, 140. Dancing the polka heads the list among the dances. Sewing and peeling potatoes demand 40; writing, 10–30; carpentry, 137–176; sawing wood, 400; and coal-mining, 114 to 205, according to the nature of the work.[1] Using such figures we can estimate the theoretical output of anyone if we know his day's activities and thence estimate the Calories he should take as food. And doubtless such figures would show some sort of correlation with reality if we accept them *as an average figure only*.[2] Thus we might assess the coal miner's work as needing 3500 Calories per day and if we were feeding all the workers in a mine all the time we should be wise to see that the average Calorie value of the diet fed reached a level of 3500 + 10 per cent. = 3850 Calories per day. It would be foolish to insist that everyone engaged in mining took his 3850 Calories; that one who took less was undereating and that one whose intake was near the 5000 level was greedy. Figures will be given later to show how absurd such an attitude would be.

[1] Figures collected by J. R. Marrack. (1942). *Food and Planning*. Gollancz, London, 35, 36.

[2] Interesting examples of such calculations are given by Marrack. *Op. cit.* 36, 39.

Meanwhile we must record the general opinion that the average Calorie intake for the adult male should be about 3000 and that of the adult female, 2500 (or it may be 2200), but this figure is by no means universally accepted. There are always people, even scientists, who think that it might be lower. The military mind seems to think that wars may be won by "pulling in one's belt" despite evidence to the contrary. It is almost certain that one factor in the winning of the war of 1914–18 was the better feeding of the armies and the populace of the United Nations as against that of the central European countries. Whereas we in Great Britain were obtaining more than 3000 Calories per head per day, the official (and therefore putative) figure for Germany was 1600, and in actual fact much less. In 1936, thirty-three potential recruits to the British army, turned down for physical unfitness, were won back to normality by a special course of training plus a diet which supplied 4738 Calories per day. At the end of three months twenty-four were up to the physical requirements and six were on the border line.[1]

Moreover, experiments made by Benedict, which have been quoted to uphold the idea that 3000 Calories per day is luxurious do not seem to bear that interpretation. Two squads of students cut down their food intake to about 2000 Calories per day for a period of fifteen weeks. The effect was to lower the body weight till a new equilibrium was reached and there was a fall in basal metabolism. This showed that it is possible to keep a constant, though relatively low bodyweight, on a lower Calorie intake. Further, some of the squad could maintain athletic ability of no mean order. But they were anæmic, they felt the cold more than fellow students, demanded excessive bedclothes even though sleeping in a centrally heated bedroom, were disinclined to patronize the warmed indoor swimming bath, cut down involuntarily the amount they walked, and *could not keep their minds off food.*[2] This does not suggest that a Calorie intake of 2000 per day is satisfactory for American college students who to some extent could regulate their extra activities. Much less does it suggest that 2000 is enough for the average man who has to perform muscular work to schedule.

It is true that the League of Nations Technical Commission assessed the minimal figure for male *and* female at 2400 Calories, but the male's need was subject to various additions to compensate for activity, raising it somewhat for light work and for moderate work to between 2800 and 3200. Bacharach and Drummond suggest a marginal figure of 3000 Calories for the male and 3500 as an optimal figure. The Ministry of Food during the war of 1939–45 has aimed at 3600 as a gross figure.

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[1] Quoted from Marrack. *Op. cit.* 157.

[2] Marrack. *Op. cit.* 42. Squad A's hæmoglobin level after 2 months of the diet lay between 70 and 80 Sahli (81 to 93·5 Haldane), Squad B's fell in 22 days from 87 to 81 (Sahli).

It is clear that there is no absolute agreement. Nor is this astonishing. We have not yet made up our minds at what we are aiming, nor do we know yet how what we may be aiming at is to be obtained. Do we wish merely to keep people alive, or to obtain the maximal physical efficiency regarding man as a machine from a given amount of Calories or to ensure the "buoyant health," which seems to be the goal of American dietitians? Should we encourage the production of the small wiry person or the giant; is 5 ft. 7 in. our goal or 6 ft.?

We are not saying this to decry any attempts at fixing the Calorie figure. We are sure that on the whole where people take 3000 Calories or more per day the public health is sounder, the moral higher, the expectation of life longer. The diet of Southern India and Assam yields about 2000 Calories per day, though Northern India has a more generous diet. The expectation of life of a new-born child in India is 27 years while that in England is 61.[1] One important factor in causing that difference is food. Accounts from enemy-occupied Europe tell a similar story. France has been obtaining only 1000 Calories per head per day and the health and morale were appalling.[2] In Belgium in 1942 the basic ration was 1230 Calories and as a consequence tuberculosis had increased greatly. In Greece according to Cawadias [3] they "ceased bothering about tuberculosis," other diseases being still more rampant. In Great Britain it is notorious that health during 1939–45 has been better than ever before—despite all drawbacks of black-out, ventilation, overwork and anxiety—and part of this must be due to the fact that we kept the Calories up above the 3000 level, though perhaps the main result is due to the better distribution of food, particularly the distribution of milk, among the people.

Calories matter. Deprivation of calories is starvation. Without water the body dies after a few days. Without Calories it may last some 50 days or even more. Under-supply of Calories provokes a continuous hunger when the mind cannot "keep off the subject of food." In fact if instinct be a guide in the choice of food its clearest effect is in the search for Calories. There seems to be some self-regulating mechanism, often, it is true, overlaid by custom and habit, which guides us in the right choice of the amount necessary. As Du Bois, Marrack and others have pointed out, many people remain constant in body weight for periods of 20 and 30 years as the result of this self-regulating mechanism, and it is Calorie intake which largely governs body weight. And as this mechanism, when allowed to work unfettered by supply and ability to purchase food, seems to set a value around 3000 Calories per day as the figure of choice, we may accept it, for the present, as the desirable though perhaps marginal average figure for the adult male doing light work·

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[1] ORR. (1943), *Food and the People*, The Pilot Press, London, 45.

[2] *Lancet*, (1943), **2**, 703.

[3] *Loc. cit.*

That this figure may be expected to increase on the average with the intensity of the physical work done is obvious and there are many results obtained which indicate that this is true. We quote figures from previous editions of this book and later figures collected by Marrack.[1]

Other figures are:

U.S. Army Ration	3851
Hostels for Munition Workers (1917)	3463
American professional men	3325
Labourer's family, Edinburgh	3228
German soldiers, war footing	3093
"Fully-fed" tailors, England	3053
Miners and their families (1924)	3035
Rowntree's Family Budgets (pre-1914)	3000
Essex Agricultural Labourers (1925)	2872
St. Andrews Families (1931)	
Professional Classes	3638
Intermediate Classes	3423
Shopkeepers	3354
Skilled workers	3239
Unskilled workers	2776
Unemployed	2089
Cardiff Families (working-class) (1932)	3174
Reading Families " (1932)	2906

It will be observed that on the whole the results are fairly uniform. Where poverty exists (e.g. the Essex Agricultural Labourer, 1925, or the unemployed from St. Andrews, 1931), there the figures are low and may be regarded as insufficient for health. Where there is a freedom, perhaps hard-won, to spend freely on food the figures are somewhat higher than is necessary. Certainly where people are well-to-do the Calorie value of the diet rises. None the less the figures in the later researches are not far from the 3000 level. If we average those from the Medical Research Council's Special Reports from 1917 to 1932 we obtain a figure of 3098. Figures collected by Widdowson[1] give an average of 3067.

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[1] *Op. cit.*

Turning to figures from people engaged in more strenuous livelihoods and avocations we may quote: Lumbermen, Main, 6995; Miners, Tomsk, 6015; Brickmakers, New England, 7551; Wrestler, Finland, 4,662; Wrestler, U.S.A., 4741; Olympic athletes, 4700.

Some of these figures were collected by the individual method; others are averages. Now when the people are all of an age and sex—say all adult—no complications are involved in obtaining the average figure. But in many of those given above the sexes and ages are mixed, so the figures are suspect because the method of an "index" to represent the "man value" of women and children has been used. In fact we know as yet but very little about the Calorie intakes of women and children as will be shown later. Consequently the coincidence of the average of the British figures with the magical estimate of 3000 must be viewed with suspicion. We need to start with individual dietaries collected from men, women and children in circumstances in which poverty does not limit choice of food. It might be thought that for men and women we had such figures prior to 1935, and we certainly have had some figures for children in New York and New England, which we have quoted above. But until the publication of figures for men[1] and women[2] in 1936, and the collection of over 1000 dietaries for children, still unpublished as this portion of the book was being prepared, we had no data for this country which probe the correspondence of reality with the theoretical treatment usually given to the subject. The figures are somewhat shattering to theory.

With the men, though the average figure was 3067, the variations from that mean are very wide, and it is stated by the author that "the adoption of 3000 Calories as the requirement of an individual man may be most misleading".

Perhaps it would be wise to go more closely into these figures and the way in which they were collected. We quote from the original article. "The subjects of this investigation were sixty-three healthy men of the English middle-class and all lived at their homes. Their ages ranged from 18 to 89 years. Sixty of the subjects were in regular employment, the remaining three had retired. The occupations, which were very varied, . . . were mainly of a moderately active kind, though about eight might be classed as sedentary and three as very active. None of the subjects was judged to earn an income which was too low to provide him with the food he required, so the dietaries could be considered to be freely chosen so far as money was concerned. They would all probably fall into Orr's three highest income groups.

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[1] Widdowson. (1936), *Journ. Hygiene*, **36**, 269.

[2] Widdowson and McCance. (1936), *ibid.*, **36**, 293.

"Each subject was provided with a spring balance weighing by ¼ oz. up to 1 lb., a plate on which to weigh the food and a form on which to enter results. The subjects were interviewed personally in almost every case and the exact procedure to be adopted was explained to them individually. A record was taken of their heights and weights.

"All food eaten during the period of one week was weighed. The weighings were carried out on the edible portion of the food, and where bones, skins of fruit, etc., were included this was stated so that allowance could be made in calculating the results. . . ."

It will be seen that the people concerned relied on their appetites and instincts to guide choice in the amount of food eaten and its nature. There was no stinting or deprivation due to poverty; no reason to suppose that anything but inclination led them to eat the foods they did eat and in the quantities they wanted. Yet though the mean figure was 3067, one took actually less than the "Sewing girl, London, low wage" quoted as an example of undernourishment in earlier editions of this book, viz. 1772, while another took more—20 per cent. more—than a member of a University boat crew, viz. 4955! Moreover, the highest Calorie inputs are not necessarily those of the most strenuous workers and the widest variation occurs among men of similar occupations. The university teacher of 28 years who took 1772 Calories per day was slightly overweight, while the man, one year older, an electrician, who achieved the record figure of 4955, had a normal weight for his height and age. And these were not freak figures. The spread of the individual figures was much that of a probability curve and the standard deviation 714 Calories. Reputations in dietetics have been wrecked for less than this.

Observations which have been made on diabetic patients of all ages taking insulin show that they can maintain their weight as a rule, year in year out, on diets containing C 130–150 grammes, P 70–80 grammes, and F 100 grammes, and yielding Calories 1770–1850. It is rarely that the Calories of the diet have to be raised above 2000, though this is necessary in the young adolescents or in patients with a wasting disease like tuberculosis.

Summing up the matter, we may say that though the average figure 3067 fits in very well with our theoretical calculations, nothing else does. Although there can be little doubt that *on the average* increase of physical work and increased height and weight run parallel with increase of Calorie needs, there is absolutely no ground for rigorously applying this to the individual. One man on moderate work may be consuming food appropriate to very hard work and not be putting on weight; another on light work may consume food 25 per cent. *below* the League of Nations figure and yet be putting on weight. In fact, so far as we have gone in dietetics, it is difficult when dealing with the individual male to see any rhyme or reason in his Calorie intake. There must be reasons why one man is pleonectic as regards food and another meionectic, but we do not yet know them. It is a disservice to pretend that such variations between individuals do not exist, or that we can explain them. And such considerations throw grave doubt on the usefulness of the "coefficient" or "index" (see p. 40).

Fact and Theory in the Calorie Input in Women. We have seen that the Calorie input in men when measured individually shows an enormous variation. We have been given evidence that the "average" man's input is 3000 Calories approximately. We have been given the guess that a woman's average input should be, on Lusk's and Cathcart and Murray's scales, 0·83 times that of a male, i.e. 2500 per day.

When the input of Calories in women is estimated individually[1] it is found that the spread of inputs is almost as great as that of the men above quoted. The lowest figure was 1453 per day, and this was the amount taken by a secretary leading an active life with a body nearly 12 per cent. *above* the normal standard weight and height. Nine out of the 63 women investigated were leading active lives on intakes of less than 1700 calories per day. "Three of these were housewives, two were secretaries, two were cooks, one a dietitian, and one a student, all people with free access to food." Of those on a high input, 2900–3100, two were markedly underweight for their heights, one just slightly overweight and one, a cook, 6·1 per cent. overweight. Again there is no rhyme or reason in the figures so far as can be seen.

The average input of calories was nearly 2200 Calories per day, so that if we place our credit in "coefficients" or "indexes" a woman becomes 0·73 of an adult male, instead of the 0·83 of Graham Lusk and Cathcart and Murray. It is true that the latter[2] did find, in five individual cases they investigated, a coefficient of 0·7 for the woman, but they preferred to calculate the family intake "per man" on the old conventional basis of 0·83. Estimates of the

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[1] WIDDOWSON and MCCANCE. (1936), *Journ. Hygiene.* **36**, 293.

[2] CATHCART and MURRAY. (1931), *Med. Res. Council Spec. Rep. Series*, No. 151.

Calorie input by women University students in the laboratory of one of us give figures usually below the 2400 level of the League of Nations technical committee, i.e. an index below 0·8. When, however, we note that in Widdowson and McCance's figures the index runs from 0·48 to 1·03 in individual women we may wonder if the index has any value whatever except in the minds of those who wish to make dietetics appear more " scientific " than it is. Each individual is a law to him- or herself, and so long as body-weight and activity appear to be unimpaired we cannot say that such and such a diet, deviating widely from the mean, is wrong or unsuitable.

In this discussion we have been in danger of assuming that what people do, on the average, in the way of diet is right. If the average male, not in want, takes 3000 Calories and the average female, in similar circumstances, takes 2200, then those figures become in some way right and sacrosanct. If there is any truth in the idea that our food habits are instinctive, there might be some reason in paying attention to these figures. Perhaps there is. Introspection does seem to show that so long as one is healthy and leading a healthy existence one's appetite leads one to eat an amount of food, if *simple*, commensurate with one's need. On the other hand, fashion in woman in the search for a definite silhouette, a " refined " attitude towards food or a desire for attention on the part of solicitous relatives and friends may, and frequently does, upset the instincts. We have no *a priori* reason for assuming that any of the figures obtained by observation upon man or woman are optimal figures. We do not know if all these women had taken more food (or even, possibly, less) they would not have been in better health. All we can say is that each individual diet was apparently " safe " and not obviously leading to trouble. For the present we may accept the figures 3000 and 2200 as respectively satisfactory for the average man and woman, while always admitting that the true input for any individual may range far from these means without danger of under- or overfeeding.

We have here an anomaly which needs scientific investigation. We have seen that estimates of basal metabolism do show some uniformity in that the Calorie output per square metre of body surface varies but little from the average in different individuals. Anything 10 per cent. on either side of the average figure throws doubt upon the health of the person with that variation. Yet when we investigate total metabolism we find that each person is a law unto himself. He may be 40 per cent. below the norm or 60 per cent. above it and yet appear perfectly healthy.

We must assume that man as a machine for doing physical work outside that for keeping the machine alive is a most unstandardized piece of machinery, and unpredictable till we know much more of his endocrine, nervous and—dare we breathe it in a work on dietetics—emotional make-up. It will take much more research upon individuals as individuals before we can resolve this anomaly. So far we have shut our eyes to it in spite of the publication by Graham Lusk of curves representing the Calorie intakes of three boys of different types as in Fig. 4.

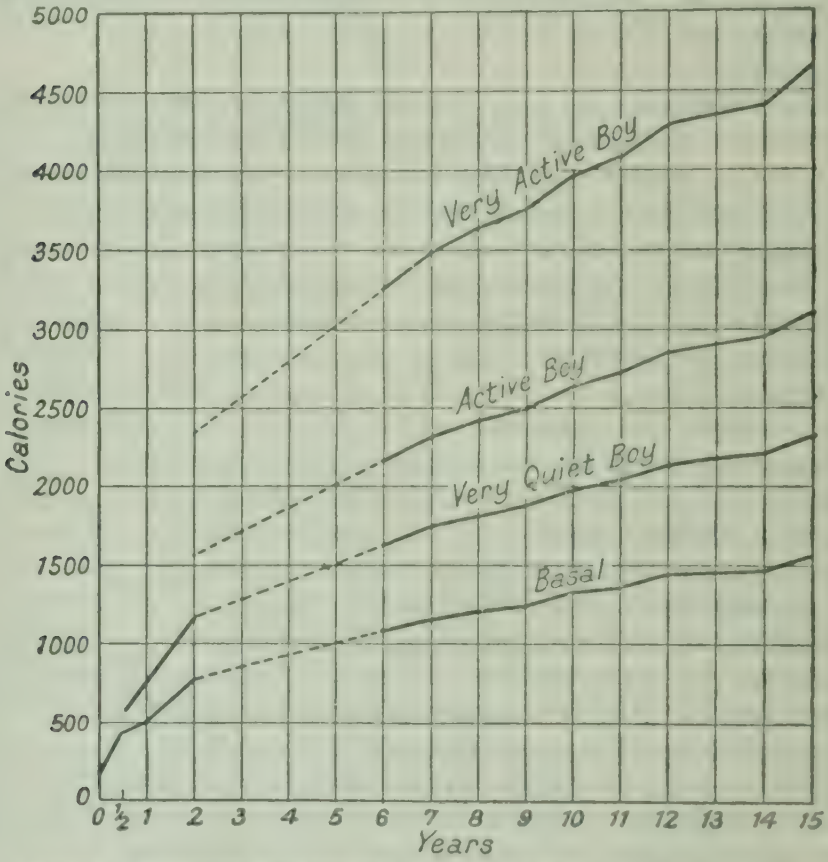

Fig. 4.—Calorie Intake of Boys of Different Activities

Theory and Fact in the Calorie Input in Children. In view of the discussion we have had above concerning the index for children and adolescents it may come as a shock and surprise that these indexes are based on little experimental work. So far as is known, with the exception of the figures of Holt and Fales already quoted, there have been published no consistent observations for any large number of individual children.

Figures have been collected in this country of the inputs of over 1000 middle-class children of all ages up to 18 by the individual method in the years immediately preceding the outbreak of the war of 1939–45. They are as yet unpublished. A preliminary account of the findings was given by McCance and Widdowson at a meeting of the Nutrition Society of Great Britain in the spring of 1944. They are sufficient to show that it is impossible to apply the index method of estimating Calorie needs to individual children. At any age we may find a child taking twice the amount of Calories (and also protein, etc.) of another child in that group. We give, with the permission of the authors of this unpublished work and with all reservations of a scientific nature, the *average* Calorie inputs at each age investigated, side by side with those of Holt and Fales,[1] the League of Nations Technical Commission, and the National Research Council, U.S.A.

Age.	McCance and Widdowson.		Holt and Fales.		League of Nations.			National Research Council, U.S.A.	
	Boys.	Girls.	Boys.	Girls.	Boys. and Girls.	Boys. with	Girls. allowance for activity.	Boys.	Girls.
1	1154	1152	950	940	840			1200	
2	1406	1431	1135	1110	1000			1200	
3	1691	1533	1275	1230	1200			1200	
4	1839	1718	1380	1300	1200			1600	
5	1732	1708	1490	1410	1400	2040		1600	
6	1940	1985	1600	1520	1400	2040		1600	
7	2178	1995	1745	1660	1680	2280		2000	
8	2170	2088	1920	1815	1680	2280		2000	
9	2443	2165	2110	1990	1920	2520		2000	
10	2501	2345	2330	2195	1920	2520		2500	
11	2521	2292	2510	2520	2160	2760 or more[2]	2760	2500	
12	2630	2370	2735	2860	2400	3000 or more[2]	3000	2500	
13	2756	2500	3040	3210	2400	,,	,,	3200	2800
14	3065	2637	3400	3300	2400	,,	,,	3200	2800
15	3400	2588	3855	3235	2400	,,	,,	3200	2800
16	3105	2363	4090	3160	2400	,,	,,	3800	2400
17	3223	2515	3945	3060	2400	,,	,,	3800	2400
18	3427	2513	3730	2950	2400	,,	,,	3800	2400

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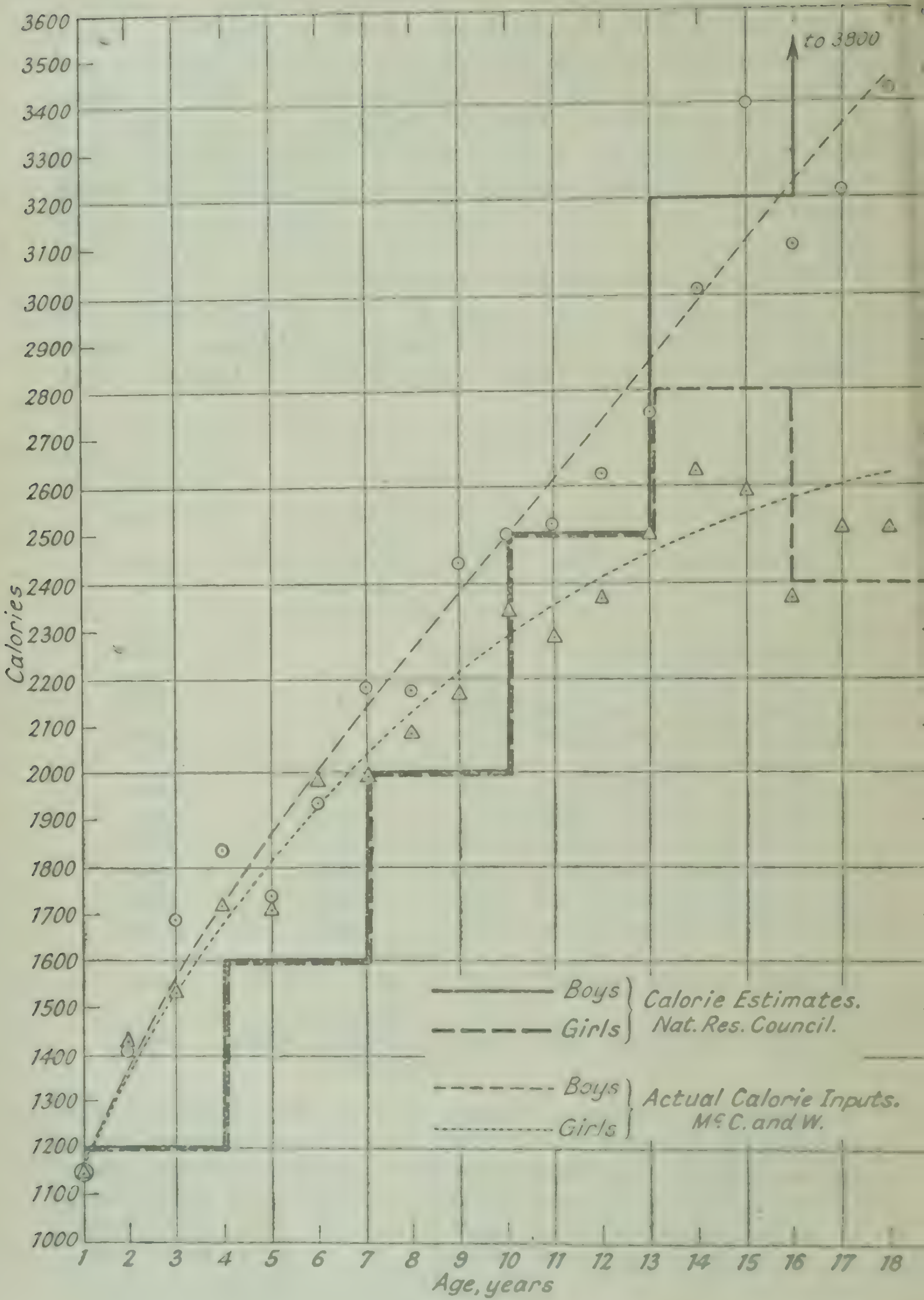
[1] HOLT and FALES. (1921), *Amer. Journ. Dis. Child.*, **11**, 1.

[2] Or more according to activity.



Calories
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
Age, years
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
to 3800
Boys
Girls
Calorie Estimates. Nat. Res. Council.
Boys
Girls
Actual Calorie Inputs. Mc C. and W.

Fig. 5.

A graph plotting the McCance and Widdowson figures against the American estimates is also given.

Before commenting on these tables we may note (i) McCance and Widdowson's and Holt and Fales' figures are based on actual measurements of Calorie inputs in educated middle-class children; the former are based on over a thousand observations, the latter on but 100. (ii) Holt and Fales' figures are "smoothed" while those of McCance and Widdowson are not. (iii) The League of Nations and the National Research Council's figures are estimates only (i.e. guesses based upon past observations, but still guesses) of what children should take.

We see that, compared with American children, English children do their eating young. They outstrip Americans by at least 200 Calories–400 Calories per day (no mean amount) at each age up to 10. If the English figures are an accurate measure of needs and not due either to greed or maternal solicitude, children fed on the League of Nations scale up to the age of 5 would be somewhat starved and on the American scale hungry up till 10 years of age.

It will be noted that an English girl of 10 is already eating as much as her mother and at 18 is still at a high level—i.e. above the League of Nations' and the National Research Council's figures.

On the other hand, adolescence in the boys does not call for such high figures as Holt and Fales and the National Research Council suggest. Thus English boys do not reach the 4000 level of Holt and Fales or the 3800 level of the National Research Council, and are well behind the still higher figures for American boarding-school adolescents given by Gephart.[1] Observations by one of us gave the input of 14 English boarding-school boys ranging in age from 14 years 4 months to 18 years 7 months, average age 16 years 5 months, as 3300 Calories, a close agreement with the average figure for the same ages of McCance and Widdowson. Although we do not admit that the practice of a section of the public, albeit an educated and well-to-do section, is a guarantee of rightness—an assumption often too lightly made—we consider these average figures of McCance and Widdowson a saner standard by which to judge the Calorie input of children than any hitherto published. Even so they must be applied in no Procrustean way to the individual child.

Summary. We have seen in this long chapter that food can be considered from the point of view of its chemical nature or of its use in the body. The first important function of food is to supply energy to the body which can be used either in maintaining the temperature of the body or conversion into mechanical or chemical (or even electrical) work. All can be measured in terms of heat. The chief sources of energy in the food are the fats and carbohydrates, though proteins can be and are utilized in the same way. The energy output of the body can be measured either by direct calorimetry or by indirect via gaseous exchange. The input can be estimated by investigation of the diet and calculation from food analysis tables. Intake equals output in experiments made to investigate this. Consequently to measure approximately the output of a person we may make an inventory and analysis of his diet and calculate his input from food tables. When this is done it is found that for the average man the daily figure is 3000 Calories for the edible portion of his food, or 2700 for intake. Consequently we say that the average man's Calorie needs per day is 3000.

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[1] Gephart. (1917), *Boston Med. Surg. Journ.*, 176, 17.

To compare families one with another a convention has been adopted that each child and each woman has a need for Calories which is some definite fraction of an adult male's need. To a woman and to each child according to age and sex a " man value," " coefficient," or " index " is given. It is assumed that from these can be calculated the Calorie needs of any family. When, however, we turn to facts we find that there is no correspondence between theory and fact for the individual and the " index " belongs to mythology. Man's Calorie intake may vary from 1700 to 5000 per day without obvious cause. A woman's may vary from 1400 to 3000 (average figure 2200) again without obvious cause. There are figures for British children in the course of publication and preliminary reports show that there is the same spread of the figures. The actual Calorie needs of a given family cannot be predicted and their Calorie input can be usefully gauged only by direct observations on each member of that family as an individual. (See also p. 263 *et seq.* and 522–3, Pregnancy.)

CHAPTER III

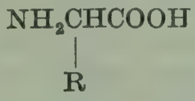
THE FUNCTIONS OF FOOD (*continued*). (II) SUPPLY OF BODY-BUILDING MATERIAL

During childhood the body grows, adding constantly to its substance, till it has reached adult stature. Even then some parts continue growing—e.g. the skin, hair, and mucous membranes of the alimentary tract. Moreover parts wear out and are replaced. Or they may be damaged by accident—e.g. a piece of skin torn away—and have to be repaired. If a particular organ be over-exercised it may respond by hypertrophy, i.e. by increase of its substance. In other words, it grows.

All such growth and repair of the wear and tear of the body need a particular type of material in the food: the ***proteins.*** Most foods contain some protein but for the purposes of practical dietetics only foods with a considerable proportion of these proteins in them are satisfactory for body-building purposes.

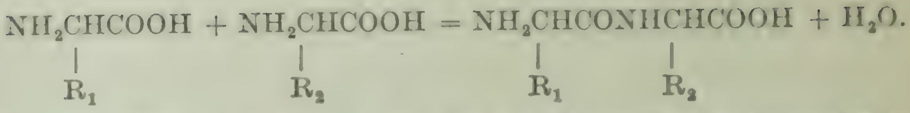
The reason is this: all living things contain proteins in their living and even in their dead parts such as nails and hair. Protoplasm, the physical basis of life, has protein as its main solid constituent. We believe that life, as we know it, is impossible without protein. Plants can synthesize the fundamental units—amino-acids—from which proteins are built up, from carbon dioxide, water, and ammonia, nitrites or nitrates; but animals cannot do this. Consequently animals must prey upon plants or upon animals which have preyed upon plants to obtain their proteins. A sound dietetics must always be based upon a sound agriculture, a fact now beginning to be dimly perceived by politicians.

Proteins possess huge molecules weighing anything from 35,000 to 210,000 times the weight of an atom of hydrogen. These molecules are built up from units called amino-acids, which link up with one another through the amino group uniting with an acid group. Amino-acids are all of the type



$$NH_2\underset{\displaystyle R}{\underset{|}{C}}HCOOH$$

where R is some simple linkage of carbon and hydrogen with possibly an amino group or sulphur. Two amino-acids can link up as in the equation

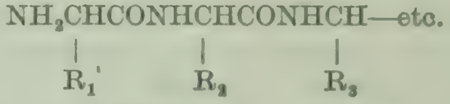


$$\mathrm{NH_2}\underset{\underset{R_1}{|}}{\mathrm{C}}\mathrm{HCOOH} + \mathrm{NH_2}\underset{\underset{R_2}{|}}{\mathrm{C}}\mathrm{HCOOH} = \mathrm{NH_2}\underset{\underset{R_1}{|}}{\mathrm{C}}\mathrm{HCONH}\underset{\underset{R_2}{|}}{\mathrm{C}}\mathrm{HCOOH} + \mathrm{H_2O}.$$

The compound (a dipeptide) can link with another amino-acid to form a tripeptide ; this with another and so on to make a long chain (polypeptide), and X-rays show some proteins to be long chains of amino-acids of which the following may represent a middle portion :

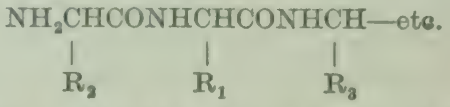
$$\mathrm{-NH}\underset{\underset{R_1}{|}}{\mathrm{C}}\mathrm{HCONH}\underset{\underset{R_2}{|}}{\mathrm{C}}\mathrm{HCONH}\underset{\underset{R_3}{|}}{\mathrm{C}}\mathrm{HCONH}\underset{\underset{R_4}{|}}{\mathrm{C}}\mathrm{HCO-}$$

As there are some 22 amino-acids available for the building of proteins and there are 250 or more links in the chain of the simpler it will be seen that some or all of the amino-acids must be repeated several to many times in the molecule. It will also be seen that there is an enormously great possibility of difference between proteins, for the amino-acids in a protein may differ in (i) their number, (ii) their nature, (iii) their mutual proportions in number, and (iv) their order. Each difference will entail a difference in the protein constituted. A protein with 200 links would be different from one with 400 links ; a protein with all the amino-acids would differ from one with all but one of the amino-acids ; a protein with much glutamic acid would differ from one with little ; and a protein with the formula



$$\mathrm{NH_2}\underset{\underset{R_1'}{|}}{\mathrm{C}}\mathrm{HCONH}\underset{\underset{R_2}{|}}{\mathrm{C}}\mathrm{HCONH}\underset{\underset{R_3}{|}}{\mathrm{C}}\mathrm{H\text{—}etc.}$$

would differ from one with



$$\mathrm{NH_2}\underset{\underset{R_2}{|}}{\mathrm{C}}\mathrm{HCONH}\underset{\underset{R_1}{|}}{\mathrm{C}}\mathrm{HCONH}\underset{\underset{R_3}{|}}{\mathrm{C}}\mathrm{H\text{—}etc.}$$

It does not follow that the chains are straight. The R_1, R_2, and R_3, etc., may attract each other or repel. They may even join up with each other and so on and form girder-like structures or frames as of a steel building.[1] Most of this is not important in dietetics, except perhaps as bearing on the digestibility of certain proteins, but what is of importance is that the nature and proportion of the amino-acids in proteins may vary, for herein lies the explanation for some food proteins being preferred to others.

---

[1] Jordan Lloyd and Agnes More. (1938), *Chemistry of the Proteins.* 2nd edn. Churchill. Astbury. (1941), *Chemistry and Industry*, 60, 491, says "that most proteins are gigantic, organized polypeptide chain systems and the chains are in specific configurations and are linked one to another . . . they are polypeptide chain systems heavily disguised."

The formulae of most of the amino-acids found in protein are here given.

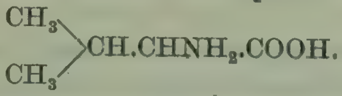
Glycine $CH_2NH_2.COOH.$

d-Alanine $CH_3.CHNH_2.COOH.$

l-Serine $CH_2OH.CHNH_2.COOH.$

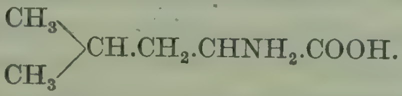
d-Threonine $CH_3.CHOH.CHNH_2.COOH.$

d-Valine



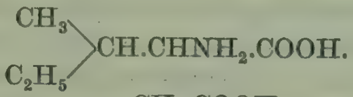
$$\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right\rangle CH.CHNH_2.COOH.$$

l-Leucine



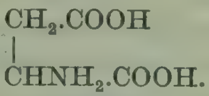
$$\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right\rangle CH.CH_2.CHNH_2.COOH.$$

d-Isoleucine



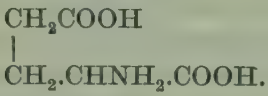
$$\left.\begin{matrix}CH_3\\C_2H_5\end{matrix}\right\rangle CH.CHNH_2.COOH.$$

l-Aspartic acid



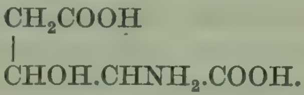
$$\begin{array}{l}CH_2.COOH\\|\\CHNH_2.COOH.\end{array}$$

d-Glutamic acid



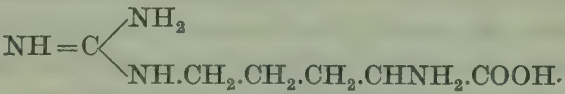
$$\begin{array}{l}CH_2COOH\\|\\CH_2.CHNH_2.COOH.\end{array}$$

d-Hydroxyglutamic acid.



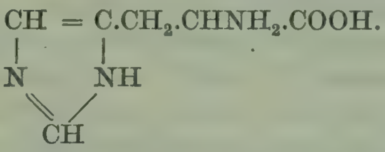
$$\begin{array}{l}CH_2COOH\\|\\CHOH.CHNH_2.COOH.\end{array}$$

d-Arginine



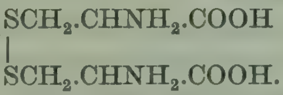
$$NH{=}C\left\langle\begin{array}{l}NH_2\\NH.CH_2.CH_2.CH_2.CHNH_2.COOH.\end{array}\right.$$

l-Histidine



d-Lysine $CH_2NH_2.CH_2.CH_2.CH_2.CHNH_2.COOH.$

l-Cystine



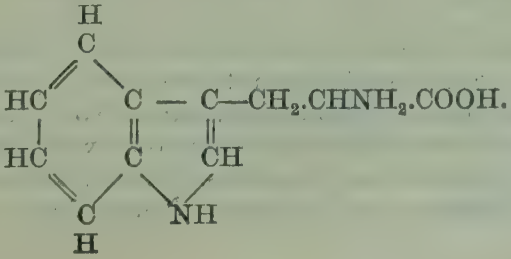
$$\begin{array}{l}SCH_2.CHNH_2.COOH\\|\\SCH_2.CHNH_2.COOH.\end{array}$$

l-Methionine $CH_3S.CH_2.CH_2.CHNH_2.COOH.$

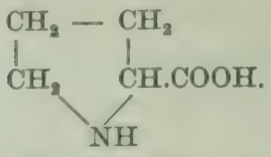
l-Phenylalanine $C_6H_5.CH_2.CHNH_2.COOH.$

l-Tyrosine $C_6H_4OH.CH_2CHNH_2COOH.$

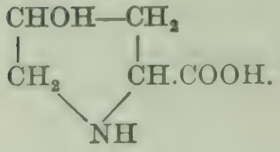
l-Tryptophane



l-Proline



l-Hydroxyproline



Some of the amino-acids in protein are utterly indispensable in human diet, others can be manufactured by the body if the indispensable ones are given. We are fairly sure that the following amino-acids are indispensable—this has been proved by experiments on the laboratory rat—tryptophane, lysine, histidine, methionine,[1] threonine, phenylalanine, and the leucines, and we are certain about phenylalanine or tyrosine and tryptophane in human nutrition because of the experiments which have been made on human beings on the body-building value of gelatin.[2] This protein, which is made by boiling tissues of animals which contain much connective tissue (skin, bones, and meat with much tendinous tissue), lacks the amino-acids tryptophane, valine, and isoleucine, and has very little of tyrosine and cystine (many workers say none). Consequently by *itself* it is of no use in building up human or other animal protein. This has been abundantly proved from the time of Voit onwards, and for long, gelatin, though apparently consisting of chains of amino-acids linked as they are in protein, was denied the name of protein. (It was called an albuminoid, a substance like a protein, chemically but not physiologically a protein because it could not sustain life. The term still lingers on though forty years out of date, and either in the form " albuminoid " or as a " protein sparer " is a useful danger signal to the intelligent reader.)

A similar substance is zein, an alcohol-soluble protein in maize or Indian corn (*zea mais*). It lacks tryptophane and lysine and though useful in conjunction with other proteins is useless by itself.[3, 4] The low biological values of gelatin and zein, though of extreme interest to the physiologist are of no real importance in dietetics.

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[1] ROSE, in the U.S.A., has shown that methionine is indispensable for man. For the work on rats see ROSE. (1938), *Physiol. Rev.*, **18**, 109.

[2] ROBISON. (1923), *Bioch. Journ.*, **16**, 3, gives the bibliography from Voit's investigations up to his own work upon the subject.

[3] WILLCOCK and HOPKINS. (1906), *Journ. Physiol.*, **35**, 88.

[4] VICKERY and OSBORNE. (1928), *Physiol. Rev.*, **8**, 393.

None the less, the dietitian must keep the importance of the individual amino-acids in mind and realize that the common plant proteins—the cereal proteins—are relatively deficient in such essential amino-acids as lysine, methionine and tryptophane. Indeed there are some who maintain that, instead of discussing minima and optima of proteins, attention should be paid to the minima and optima of each indispensable amino-acid. This point of view has been confirmed by discoveries concerning the immense importance of the amino-acid methionine in the years 1942–45 for the normal health of the liver and for regenerating damaged liver and skin tissues. When the diet of the laboratory rat is deficient in protein, but in no other dietary factor, a severe necrosis of the liver cells occurs.[1] If the diet contains very little protein, i.e. less than 100 mg. of casein per day, the condition does not occur, presumably because the animal lives on its own tissues, breaking up the muscle protein to obtain the essential amino-acids. But on a diet with between 200 and 500 mg. of casein per day, acute necrosis develops. On more than 500 mg. the liver is not affected. The necrosis, usually occurring when 200–500 mg. of casein is eaten, can be prevented by adding methionine in the proportion of 8 per cent. of the total protein of the diet. Yeast protein, which contains very little methionine, cannot prevent the necrosis, even when 1000 mg. are given per day.

We have already noted that methionine is an essential amino-acid in human nutrition and it is noteworthy that outbreaks of massive necrosis of the liver occur among people living on diets grossly deficient in proteins.[2] Further, milk has been successfully used in the wars of 1914–18 and 1939–45 to combat the necrosis of the liver due to trinitrotoluene (T.N.T.) poisoning. This milk supplied extra methionine.

For long it has been known that severe burns induce a marked output of nitrogen via the urine. The same is true for fractures, tissue laceration and extensive operations. Croft and Peters[3] have investigated this loss of nitrogen in burnt animals and have shown that increased protein in the diet mitigates this loss and further that extra methionine given in the proportion of 1 per cent. of the total protein works in the same direction. The other amino-acids tested, alanine, cysteine and a mixture of synthetic amino-acids failed to prevent the loss of nitrogen in the urine. The authors suggest that this loss is due to a call of the body, suffering from burns, for a particular amino-acid (methionine) with a consequent raiding of the whole protein molecule. These observations on liver necrosis and burns (and presumably also in fractures) have an obvious bearing on human nutrition in health and disease. Methionine also has a relation to "cirrhosis" of the liver. Dogs, depancreatized and treated with insulin, often die with an extreme fatty infiltration of the liver.[1] Best found that choline given by mouth prevented this phenomenon, and suggested that the choline is necessary for the phosphorylation of the neutral fats. A similar condition can be produced in rats by feeding on a high fat or a high carbohydrate diet and prevented by choline (5 mg. per day). Later it was discovered that casein, even if it did not contain any choline, prevented the infiltration and the subsequent damage which this infiltration produces. Egg albumen, beef muscle protein and edestin (from hemp) were just as good as casein, but gliadin, the wheat protein which does not contain lysine, was less active, while zein (no tryptophane or lysine) and gelatin (no tryptophane, phenylalanine, cystine and tyrosine) had no effect at all. An investigation into the individual amino-acids showed that cysteine greatly increased the fatty change but that methionine cured it and was one-twelfth as effective as choline. The striking difference between the effects of the two sulphur-containing amino-acids may be due to the linkage of sulphur in cysteine with a hydrogen atom whereas in methionine it is linked with a methyl group.

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[1] GŸORGŸ and GOLDBLATT. (1939, 1940 and 1942), *J. Exp. Med.*, **70**, 185; **72**, 1; and **75**, 355. HIMSWORTH and GLYNN. (1945), *Proc. Roy. Soc. Med.*, **38**, 101.

[2] HIMSWORTH and GLYNN. (1945), *op. cit.*

[3] LANCET. (1943), **1**, 266.

If the condition was allowed to continue in rats, the fat disappeared, but the portal connective tissue greatly increased. The cells showed no massive necrosis at any time. The condition took from 2½ to 5 years to develop and the final stage closely resembled Laennec's multilobular cirrhosis. The animals showed no sign of acute illness but usually died of an intercurrent infection.[2]

Formerly multilobular cirrhosis of the liver in man was thought to be due to an excess of alcoholic drinks in the diet. But this view was discredited because cirrhosis occurs among people and races who do not drink alcohol,[3] and no constituent of alcoholic drinks (alcohol, fusel oil and the like) produces it experimentally. The present observations suggest that the condition may be due to either a high fat or high carbohydrate diet associated with a low protein intake. Alcohol may play an important part by reducing the amount of food eaten because of, either the associated gastritis or lack of money to buy the food. The first effect would be the production of a fatty infiltrated liver, and then in the course of years this would set up a fibrosis.

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[1] BEST and HUNTSMAN. (1932), *J. Physiol.*, 75, 405.

[2] HIMSWORTH and GLYNN. *Op. cit.*

[3] It is sometimes seen in animals such as guinea-pigs bought from animal dealers.

Once again we meet an important bearing of protein and the particular amino-acid methionine on human nutrition in health and disease.

BIOLOGICAL VALUE OF PROTEINS

Of proteins such as gelatin we say that they have no *biological value*, which means that, taken by themselves as the sole source of protein, they have no power of building up the animal body, but they are, of course, of value in conjunction with other proteins.

A few words of definition and on the measurement of this characteristic are essential. The " biological value of a protein " means its power of replacing the protein of the body lost by wear and tear, and if 100 parts of the protein replace 100 parts of body protein we say that its biological value is 100; if it replaces but 60 parts of body protein, then its biological value is 60. Clearly if it cannot be used to replace human protein its biological value is zero. Of course protein may be used for growth, and it is conceivable that the biological value for growth may be different from the biological value for replacement of loss by wear and tear.

The measurement of the biological value of any one protein is a very difficult task—more difficult than most observers are aware till they are precipitated into the work.[1] On human beings it is incredibly difficult.

The first step is to reduce the subject's metabolism to the minimal amount of protein possible, i.e. by feeding him on massive amounts of carbohydrates and fat but starving him of protein. The body then slowly settles down to an output of (say) 3 grammes of nitrogen a day,[2] which is equal to a loss by wear and tear of $3 \times 6{\cdot}25$ grammes protein $= 18{\cdot}75$. You then add to the diet, step by step, increasing amounts of the protein under discussion till the intake of protein via the intestinal epithelium exactly equals the loss of protein from the body as measured by the nitrogen in the urine and fæces —till, in other words, the subject is in " *nitrogenous equilibrium*." Theoretically, if it takes 37·5 grammes of the tested protein to get the body into nitrogenous equilibrium, its biological value will be

$$100 \times \frac{18{\cdot}75}{37{\cdot}5} = \frac{100}{2} = 50.$$

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[1] MARTIN and ROBISON. (1922), *Bioch. Journ.*, **16**, 401.

[2] As an example from actual experiment 2·29 grammes in the urine and 0·8 in the stools.

Martin and Robison showed that it was not necessary to get the body into nitrogenous equilibrium, for the biological value can be calculated from the slope of a curve relating the intake and output of nitrogen of the body at stages below the point when equilibrium is reached.

Early work by Voit and Korkunoff showed that nitrogenous equilibrium could be reached at a lower level with potato protein than with wheat protein ; Rubner and Röse confirmed this observation ; Karl Thomas extended it to a series of food proteins ranging from those of milk to those of cherries and spinach and including cereals, meats, shell-fish, and bony fish. Though no one accepts the actual figures he gave (100 for milk proteins, 105 for beef proteins, 95 for fish proteins down to 33 for maize proteins) it is admitted that the *order* in which he placed the proteins was right : animal proteins at the head of the list, potato and rice proteins nearly as good, wheat proteins next, and maize somewhat lower on the list.

The difficulty of carrying out the estimations on man (see Martin and Robison's account of this) has led to the use of growing of adult rats for this purpose. One has to admit that this introduces a doubt in the way of accepting the results : may not a protein have a biological value for the rat different from that for man ? The doubt is reasonable. Man's needs are bound to be different from the rat's, but probably similar as regards proteins.

The results of all methods have been collected by Boas-Fixsen.[1] There is very close agreement between them. They all put milk and egg proteins at the head of the list (which after all is not astonishing in view of their function), with meat and fish proteins as runners-up. Next come the cereals, followed by the pulses, with the nut proteins bringing up the rear. There is some evidence that the cooking of proteins lowers their biological value.

The majority of experiments have been made on the mixed proteins of a food-stuff. Thus the proteins used have been the mixed proteins of milk and not the individual proteins—lactalbumin, caseinogen, and lactoglobulin. When experiments are made with purified separated proteins it is almost invariably found that the mixed proteins have a higher biological value than either component of the mixture. Thus a mixture of lactalbumin and caseinogen gives a better result than either protein separately. The glutenin and the gliadin of wheat have low biological values when fed separately but when fed together have a much higher biological value. The reason is that gliadin has but little lysine in its molecule while the glutenin is *relatively* lysine rich. Consequently the glutenin can *supplement* the effect of gliadin. Similarly gelatine, which by itself has no biological value, can supplement the effect of wheat proteins because it has thrice as much lysine as glutenin.

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[1] Boas-Fixsen. (1935), *Nut. Abst. and Rev.*, **4**, **447**.

The bearing of this upon the practice of dietetics is as follows:

1. We deal in dietetics with mixed proteins and consequently the biological value of isolated proteins is of theoretical interest only. Thus the low biological values of gelatin and zein do not much concern us for no one is going to feed either an abnormal or normal person upon either of those proteins alone. Nor on the other hand need we exclude gelatin from a diet because it has a low biological value. As we have seen it actually enhances the biological value of wheat proteins.[1]

2. We have experimental reasons for advocating a dietary in which the proteins are well mixed.

3. We are practically forced into the position of advocating that there should be some food with protein of the highest biological value in the diet every day. The function of this protein is twofold: (*a*) it can be used directly for body-building with as little expenditure and waste of chemical energy as possible, and (*b*) it enhances the biological value of the other proteins in the diet. It is difficult to say which is the more important function.

It is a dogma among dietitians, in which we heartily concur, that it is of great importance to include a measured amount of first-class protein, i.e. protein of high biological value, in the diet of every man, woman, and child, and more particularly in the diet of those who are building body tissues or manufacturing proteins: children, convalescents from a wasting illness, pregnant and nursing women. By proteins of high biological value we mean those of animal origin, the proteins of milk, eggs, meat, fish, and cheese.

Daily Intake of Protein

As dietetics is a quantitative subject two questions at once arise: how much should our *total intake of protein* be per day? and how much *first-class protein* should there be? We have to admit that though we can give practical answers which are based on empiricism we have little incontrovertible fact. We can say that for a male adult the total intake of protein may reasonably be taken as

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[1] Nor, it may be urged, should we, on these grounds, extol the "strengthening" values of jellies and soups, for these rarely contain more than 5 per cent. of gelatin. In fact the physiological merits and demerits of gelatin have received far too much attention in dietetics. Its value in diet is mainly culinary and æsthetic.

80–100 grammes per day of which nearly one-half should be of first-class quality, because we know that these estimates generally "work." The League of Nations put the figure for total proteins at 1 gramme per kilogramme body weight, or 70 grammes per male, and the National Research Council of the U.S.A. adopts the same figure. But we shall do wrong if we proclaim that these estimates are right for every living male and are established upon sound scientific bases.

An experimental figure for total protein required in the average male has been reached in the following way. Subjects are put upon low protein intakes which keep them approximately in nitrogenous equilibrium. The amounts of protein are gradually increased and the intake nitrogen balanced against the output of nitrogen in the urine. It is found that very often equilibrium or even gain will be reached at a lower figure on one day or in one person than in another. Thus an intake of 8 grammes of nitrogen (i.e. 50 grammes protein) may produce a positive balance (i.e. gain of nitrogen to the body) in one person or at one time and a negative balance (i.e. loss) in another. Ideally after the lowest point at which equilibrium is reached the intake ought to balance the output, but the reason why this is rarely or never attained is that protein is mobilized and catabolized at times independently of the intake, or manufactured from amino-acids which arose from proteins digested on previous days. If now we plot intakes against outputs we find that the balances fall roughly on two parallel lines as in the diagram (Fig. 6). The negative balance figures are above the line for ideal balance and the positive below. On the line for ideal balance we can find a spot equidistant from the negative and the positive lines. This may be assumed to give the figure for the ideal intake at which nitrogenous equilibrium can be maintained indefinitely. The actual figure is 8·35 grammes nitrogen, which equals 52·4 grammes protein per day.[1]

Experiment therefore seems to suggest that a normal man could live on 52 grammes of protein per day so long as he remained in health. To guard against the inevitable upsets of the ideal routine it has been suggested by Sherman[2] that we should have a margin of at least 50 per cent. above the minimal figure. If we agree with this assumption we reach, as an advisable figure, 52·4 plus 26·2 = 78·6 grammes or about 80.

Now such a figure is a very commonly occurring one in the diets of the type of person who would carry out such metabolism experiments. It is approximately 1 gramme of protein for 1 kilogramme in weight. And if we assume that the same holds good for women as well as men, then the woman's intake of protein should be about 56 to 60 grammes per day.

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[1] LEITCH and DUCKWORTH. (1937), *Nut. Abst. and Rev.*, 7, 257.

[2] SHERMAN. (1938), *Chemistry of Food and Nutrition.* The Macmillan Co., New York.

This estimate has been very widely adopted. It was Sherman's original suggestion and, as stated above, it has been adopted by the League of Nations Technical Commission on Nutrition and the National Research Council of the U.S.A. Examination of the nitrogenous output of laboratory workers often corresponds with the estimate. And we may as well accept this figure for the average adult male until we have something more certain to replace it.

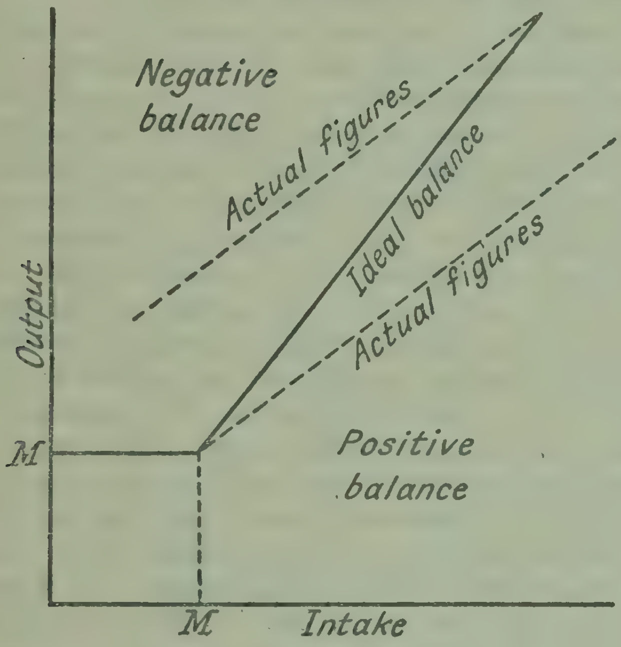

FIG. 6.

It is by no means accepted by everyone. There are those who maintain that the figure is too high. There are some who aver that it is too low. Sometimes these attitudes are based on experiments on a few isolated individuals, but more often, it seems to us, there is more prejudice than science behind them. A high protein diet usually means a high meat diet and those of us who like meat, throwing back to the hunting prehistoric ancestors of all of us, exalt the value of proteins in the diet. There is an exploded view that meat is essential for muscular work; the breadwinner must have meat. On the other hand, protein foods are expensive. Economy demands a low consumption of protein, though, as a matter of fact, a diet in which wheaten bread is present in large amounts is a high-total protein diet. Vegetarianism, and the emotional trends which make some people take up vegetarianism, are on the side of a low protein diet. The state of war has proved to many of us that we can subsist on a low protein diet. Before this last war a sentimental adulation of the peasant way of life was fashionable, and peasant diet is often a low protein diet.[1] Finally—and this consideration seems to us to be important—there is a big gap between the amount of protein necessary to replace the loss due to wear and tear and the amount which is recommended above, viz. 70 grammes per day of total protein.

Before discussing this serious discrepancy let us assemble a few of the facts known about the minima claimed. Nitrogenous equilibrium has been obtained on so low an intake of potato proteins as 25 grammes, of wheat proteins at 60; Martin and Robison put the figure for milk proteins at 38 and wheat proteins at 69. On long extended dietary regimes Chittenden, the pioneer of the low protein (and low Calorie) diet, showed that his average intake was only 36, though his athletes took amounts which, as Marrack points out,[2] were not far from the League of Nations standard. Hindhede maintains that he and his laboratory assistant Madsen remained in nitrogenous equilibrium on as little as 22 grammes per day, year in year out, though his compatriot Johanne Christiansen will not allow that his experiments are trustworthy. Röse, whose work seems to be best authenticated, lived for 15 years on a diet of 38 to 40 grammes of protein per day and at the age of 70 could walk for 16 hours a day and climb 11,000 feet on a diet containing somewhere about 25–30 grammes. It is true that he suffered from numerous colds, but his physical capacity would put most of us to shame.

On the other hand, a collaborator, Schmid of Thun, Switzerland, found that *he* could not live on Röse's 29 grammes per day and considered that it was not possible for *him* to maintain health on less than 60 grammes per day. Consonant with this, Süsskind, who weighed at the time of the experiment but 52 kilogrammes, found that he could not live on as little as 63 grammes. The League of Nations figure, 1 gramme per kilogramme, was not enough for him. Corry Mann remained in health when his intake was between 60 and 65 grammes of which nearly 42 were animal protein, but failed when he cut down the milk protein even though he replaced it by meat.

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[1] This seems to be at the back of Terroine's views quoted below. It may reasonably be pointed out that the non-peasant agricultural methods of Great Britain prior to 1939 produced more food—much more food—per person employed, than in any European country run on peasant cultivation. As there is a world shortage of food the less said about peasant cultivation of the soil the better.

[2] MARRACK. *Food and Planning*, 49.

What are we to make of this diversity of opinion and experiment? We cannot throw overboard all the low figures by impugning the scientific methods of the observers, nor need we attribute to those of the higher figures psychological instability due to the monotony of the diets they consumed. It may easily be that each person has his own specific level of intake. We know [1] that men in good health and having an income sufficient to meet demands for food take from 53 grammes to 167 grammes per day. In these estimates there was to be found little or no correlation between the size of the figures and the weights, ages and activities of the consumers. The protein inputs ran mainly parallel with the Calorie figures: a high-protein inputs nearly always accompanied a high Calorie intake. The frequency distribution diagrams of total protein and of Calories showed considerable likeness. All we can say about such figures is that some people eat more than others without apparent reason and perhaps we may say also of the experiments on protein minima that some people can attain minima unattainable by others. At any rate it should make us very chary of cutting people down to the minima of Chittenden, Hindhede or Röse. In fact some people would go so far as to say that in prescribing a diet for a nation or large group of individuals you should legislate for a maximal intake rather than the minimal, lest some should not reach a subsistence level.

Now is there any explanation of the fact that though the wear-and-tear loss of protein in the body is at the level of about 18–20 grammes a day, most of us take 60 or 70, or even more protein to replace this amount? The wear-and-tear loss is due partly to the growth, and subsequent loss, of nails, skin and hair. The skin is continually, though usually imperceptibly, being sloughed off. The alimentary and respiratory tracts desquamate gently. Mucus produced by each tract is lost to the body. Further, such a secretion as adrenaline, which must be manufactured from the tyrosine or phenylalanine of the protein eaten, is oxidized and lost. Some of the creatinine lost in the urine also must come from the breakdown of amino-acids in the body. Enzymes also are excreted in urine and fæces. In addition, it is usual to imagine that the tissues in their activity wear out and let proteins, especially perhaps nucleoproteins, out into the lymph and blood stream after which they are broken down into their component parts and excreted as carbon dioxide, uric acid and urea. The wear-and-tear protein is pictured as the protein which has been built up into the tissues or secretions of the body and as the result of wear and tear has been "rubbed off" those tissues or excreted because no longer wanted. This view of wear-and-tear protein metabolism was developed by Folin and by him dubbed "Endogenous protein metabolism." The metabolism of any protein (in the form of amino-acids) which was not built into the tissues of the body but used for combustion and the production of Calories was termed "exogenous protein metabolism."

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[1] WIDDOWSON. (1936), *Journ. Hygiene*, **36**, 269.

There is apparently a big gap between the figures for the necessary minimum wear-and-tear protein, i.e. the endogenous protein metabolism, and the total protein metabolism. Most of us, though not the Chittendens, the Hindhedes and the Röses, live a prodigal existence, throwing most of the protein we eat on the bonfires of the body to produce energy. It is even worse than this. Protein has a "specific dynamic action," as it was termed by Carl Voit, its discoverer.

When food is fed to the body in amounts which should theoretically cover the output of Calories the body promptly steps up its output to a still higher level. There is a "luxus" consumption on the part of the body—it apparently finds an increase of income irresistible and behaves in a spendthrift manner. Now protein has an effect on expenditure of Calories far greater than that due to fats and carbohydrates. Whereas these raise the level of expenditure some five per cent. above the original level, protein may raise it by 30–37 per cent. Thus in an experiment by Voit, often quoted, an amount of protein which on combustion by the body theoretically should yield 100 Calories, evoked an outburst of 137 Calories, and Du Bois[1] calculates that at least 30 per cent. of the available Calories of a large beefsteak breakfast eaten by himself went in this wasteful specific dynamic action. For the heat has to be wasted; it cannot be used for muscular energy. It is true that it can be used to keep up the body temperature. In animals exposed to a temperature approaching freezing point, the specific dynamic of protein is low and only rises to its extreme when the surrounding temperature of the air is tropical. But man everywhere contrives by clothing and housing, even within the Arctic Circle, to maintain a tropical or subtropical temperature next to his skin, consequently protein consumption has nearly its full specific dynamic action, and therefore protein consumption appears to be an extravagance.

The cause of this action, though investigated for many years by Graham Lusk and his pupils, is still somewhat obscure. As said above it is not evident when the temperature of the air surrounding the body is low. Nor is it present when protein is used in manufacture of fresh tissue, or, as Folin would put it, for endogenous metabolism. It appears only when protein is fed in amounts considerably greater than those needed to replace "wear-and-tear" protein. In fact it is conceivable that if we took protein in small amounts at frequent intervals throughout the day there would be no specific dynamic action evidenced. It is known from the work of Voit and Graham Lusk and his pupils that it is not the digestion of protein which causes it. Each individual amino-acid has its own specific dynamic action and the results are additive. The specific dynamic action of a protein is the sum of the actions of each of its contained amino-acids. Therefore, since the action of glutamic acid is less than that, say, of alanine, the specific dynamic action of a protein with much glutamic acid in its constitution (e.g. the cereal proteins) is less than that of a protein with a greater proportion of the other amino-acids (e.g. meat proteins).

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[1] Du Bois. (1936), *Basal Metabolism in Health and Disease.*

The case against high-protein consumption, on these grounds, appears to be getting strong. All the protein we eat in excess of that necessary to replace wear and tear is apparently tossed on to the bonfires of the body, there to provoke an extravagant and useless waste of heat not only by the combustion of its component amino-acids but of fat and carbohydrate as well. We leave out of this indictment of high-protein consumption all the supposed and largely imaginary evidence that a high-protein diet damages the kidneys or produces a high blood-pressure. The Eskimo, eating five times the amount of protein that the American of European origin eats, has no greater kidney or arterial blood-pressure troubles. Nor has the Masai with his diet of meat, milk and blood. Besides, as Marrack[1] very reasonably points out, why should we have special solicitude for the kidneys? Why not for the heart and therefore prescribe no exercise, or for the brain, and prescribe no thought? Moreover, man, ancestral man, in the million years before the dawn of civilization must have lived on a diet predominatingly protein, and we are here to tell the tale.

There is a case against a high-level consumption of protein if Folin's conception of exogenous and endogenous metabolism of protein be accepted. But is Folin's conception sound? We have assumed for years that the amino-acids arising from the digestion of protein were used in one of two ways: (i) they are destroyed at once in the liver, the nitrogen excreted as urea, and the fatty acid or the glucose formed from the residue used for fuel (exogenous nitrogen metabolism), or (ii) they are built by the body into human protein.[1] So many molecules of alanine, of phenylalanine, of lysine and so on are taken from the circulating blood, are placed end to end in their right order and riveted together, and, lo! the miracle of human protein. When, in the course of time, owing to "wear and tear," this protein is no longer serviceable, it is disintegrated into its component amino-acids and these in turn are converted into glucose or fatty acid and ammonia by the liver, and the end products lost to the body as carbon dioxide and urea. Some amino-acids built up into nucleo-protein do not reappear in the form in which they were used in the process of building, but take a different path and appear as uric acid. This process of the building of amino-acids into the proteins of the body's tissues and the subsequent disintegration of their constructions we termed "endogenous protein metabolism." This is the doctrine we have been wont to teach to our pupils for the last forty years. It is wrong.

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[1] MARRACK. *Op. cit.* 49.

Suspicions of the doctrine had been aroused by the fact that when the protein intake by the body (human or animal) is reduced to zero the nitrogen output in the urine does not at once fall to the lowest level accepted as "endogenous"; nor, again, does the output at once rise to the "exogenous" plus "endogenous" level when the intake is raised from zero to a normal figure. There may be a lag of four or five days before constancy is reached. It appears as if the body were reluctant to part with some nitrogenous material not truly "wear and tear" protein when placed in protein starvation, and also, as if, when again raised from zero to normal intake, it makes a point of restoring those reserves before excreting the same amount of nitrogenous material as it is receiving. Of course the explanation of sheer inertia could be given of these phenomena, but such explanation did not wholly quieten suspicions that the explanation lay deeper. The discovery of isotopes by Aston and the subsequent isolation in quantities of these isotopes of elements has put a means of investigation into the hands of experimental biologists which has thrown much light upon what is happening in the body in the process of protein metabolism. The result is that whereas the terms exogenous and endogenous metabolism are still useful terms, the distinction between them, once held to be so sharp, is very tenuous.[2]

It is clear that if you give an animal an amino-acid, say leucine, to eat with its normal diet you cannot discover whether that leucine is metabolized at once or if it is built up into the protein molecules of the tissues of the body. It might go via the exogenous path or it might replace a leucine in, say, the serum or the heart or even the skin proteins. No one could tell. But if it could be labelled in some way which would enable it to be identified, then we could track it down and discover if it were changed at once into urea or built up into tissue protein. We should expect that if it were given in addition to a satisfactory protein diet, one that much more than covered the needs for replacement of wear and tear of the proteins, it would be metabolized and excreted at once as urea, i.e. it would follow the exogenous path of protein metabolism, at any rate in the main.

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[1] Small amounts are needed for the manufacture of enzymes and of hormones, such as thyroxine, adrenaline, secretin and insulin.

[2] SCHOENHEIMER. (1942), *The Dynamic State of Body Constituents.* Harvard University Press.

Schoenheimer [1] and his associates have accomplished this labelling by inserting heavy nitrogen (N^{15}) into the amino-group of amino-acids and by replacing the hydrogen either of the amino-groups or of the carboxylic group with heavy hydrogen (deuterium). Feeding such amino-acids to an animal enables the observer to discover whether they are built into the protein molecules or metabolized at once. If the latter, the heavy nitrogen and the heavy hydrogen which had been inserted into the amino-group of the amino-acid would appear in the urea excreted. Supposing it is built into the protein of the tissues it can be found there or if endogenously metabolized it could be discovered in part, in the allantoin excreted by the animal.

In the first place it was found that the animals treat these labelled amino-acids exactly like the normal amino-acids. The animal body cannot distinguish between the two. One is as useful as the other in metabolism.

Secondly when labelled amino-acids are fed to the laboratory rat, mixed with a high (16 per cent.) protein diet, the tissues build into their substance 44 per cent. (labelled glycine) or 56 per cent. (labelled leucine) of the labelled acids. Intestines, kidney and spleen are the most active tissues which do this and the skin the least. Thus instead of, at the most, 20 per cent. of the fed amino-acids being concerned with endogenous protein metabolism, at least double and sometimes treble that amount was so concerned. Further, it was found that amino-acids doubly labelled, i.e. in their amino-groups and in their carboxylic groups, were not built in their entirety into the proteins of the tissues—the *amino groups parted company from their associated carboxylic groups.* Labelled leucine fed to an animal might be used in the construction of tissue protein which on hydrolysis would yield not only labelled leucine but labelled glycine. Those results show that the amino-acids continuously interchange nitrogen atoms. Glutamic and aspartic acids, acids appearing abundantly in cereal proteins but less abundantly in animal proteins are the most active in this interchange, whereas lysine, which occurs to the amount of 6·6 per cent. of human muscle protein and but 1·9 per cent. in the glutelin of wheat flour,[1] is a complete exception. It may yield up a labelled amino-group to another amino-acid but it never accepts one. It is the single indispensable chemical unit which has to be supplied as such in the diet.

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[1] For a condensed account of these experiments and a full list of literature on this topic see SCHOENHEIMER, *op. cit.*

The picture we must build up of protein metabolism is one in which the amino-acids in the circulating blood and tissue fluids are being continually exchanged with those forming part of the body tissue proteins, some *in toto* (e.g. lysine) and some as regards the carbon chain (leucine and histidine) but not as regards the amino-groups. These, too, may be held to exchange places between the amino-acids forming part of the tissue proteins and the circulating amino-acids. When an animal is in nitrogenous equilibrium the equilibrium is not a static but a dynamic equilibrium. There is a continual interchange between the circulating amino-acids and those composing the proteins of the tissues.

In fact endogenous protein metabolism and exogenous protein metabolism fade off the one into the other. All the architectural pictures we have made in the past, of amino-acids as Bausteine (building stones) and the proteins of the body as permanent buildings [2] must be abandoned unless we push the conception to an extravaganza, in which stones and bricks and chimney-pots continuously fly out of passing lorries and exchange places with similar objects in the houses on the road along which the lorries are passing.

This rapid, extensive and even violent interchange between circulating amino-acids and those of the tissue proteins is a mark of life and must sink to a lower level of activity if the circulating amino-acids are few. At what height should this mark of life be set ? Clearly the interchange cannot be so rapid if the body is at minimal protein intake. The dynamism of the proteins of the tissues is at a low ebb when the circulating amino-acids are not being continuously replaced by the products of protein digestion. Consequently we have to ask ourselves whether there is any evidence that producing this low ebb of tissue metabolism is good for one and all. A tentative answer is that while we know that some can carry on (e.g. Röse) with a low dynamic state of tissue proteins others seem to need a higher level of exchange, and that, as Sir Robert Hutchison quoted in earlier editions of this book, "In order to have enough, it is necessary to have too much." The tragedy is that probably two-thirds of the world have not even "enough." Until we have much more convincing evidence of the value of a low protein dietary we may reasonably ask that the protein intake be kept on the average at the level suggested by the National Research Council of the U.S.A., but that no one should look askance at wide departure from that level—up and down—realizing that the dynamic level of amino-acid interchange may be set at one point in one person and another in another. The least we can say is that the old conceptions of "endogenous" and "exogenous" protein metabolism, which were the strongest hypothetical backing for a low protein intake have been shown to be false. May not the supposed advantages of low protein intake be allowed to follow them into limbo ?

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[1] Quoted by MARRACK. *Food and Planning*, 45.

[2] See, for example, the picture evolved by one of us, in which different proteins are compared with cathedrals and slum tenements. V. H. MOTTRAM. (1938), *Food and the Family*. 6th ed. Jas. Nisbet.

So far we have been considering the total protein supposed to be necessary for the adult male and have accepted, provisionally, the figure of 1 gramme per kilo of body weight, the recommendation of the League of Nations and of the National Research Council of the U.S.A. This figure should be accepted as a standard of reference only, the evidence for higher or lower figures being still of doubtful value. But we have said nothing about the quantity of first-class proteins, and the Americans omit any such consideration. This we consider reasonable in the United States and Canada, for, on the average, people in those countries insist on including so much milk and so many eggs in their diet. A poor, rather marginal dietary estimate in the U.S.A. calls for 227 eggs a year or nearly 4½ per week, a figure much greater than in England, especially war-time England. And the fluid milk consumption per person in the U.S.A. is about double that in England. Except among the poor whites of the Southern States there is no need to worry about first-class proteins in the U.S.A.

It is not so in Great Britain, especially in war-time. Rationed meat, milk, eggs, cheese and bacon at the best produced only 75 per cent. of the low estimate for first-class—i.e. animal—protein which has been adopted in this country. In war-time all had to make use of the full allowance of dried eggs and milk, or have recourse to fish, game and offal (fresh or tinned), communal or other restaurants or to the black market to achieve an animal protein intake as great as the Ministry of Health recommended in

1933.[1] Before the war, it was essential to have some sort of standard of first-class protein intake to measure the dietetic value of the country's diet, even if that standard were based on guesswork. Now that the war is over it will be still more necessary, if only to ensure that controls and subsidies, introduced to the great benefit of the public health be not withdrawn.

The figure accepted by the Ministry of Health in 1933 was 37 grammes of first-class protein per day. The origin of this mystic figure is probably as follows. Carl Voit expressed an opinion that 35 per cent. of the total protein consumed should be of animal origin. This, Graham Lusk, one of his best-known pupils, expressed as 5 per cent. of the total Calories. One of us, under Lusk's influence, brought this figure back to Great Britain and retranslated it into grammes. 5 per cent. of 3000 Calories = 150 Calories. Each gramme of protein can produce 4·1 Calories; 150 ÷ 4·1 = 37 approximately. The Ministry of Health pamphlet into which this was incorporated pointed out that the figure was by no means extravagant and to make this point clear the following table is given in which is set out the amount of a food-stuff which will give the whole of a day's estimated needs for first-class protein.

A MAN'S DAILY RATION OF ANIMAL PROTEIN
(Each portion contains 37 grammes)

CHEESE.	Cheddar	4⅛ oz.
	Dutch	3½ „
	Little Wilts.	4¾ „
EGGS.		5–6
FISH.	Cod, steak, A.P.	9½ „
	„ „ steamed, E.P.	5¾ „
	Haddock, smoked, A.P.	8½ „
	„ steamed, E.P.	4⅝ „
	Herring, A.P.	7⅛ „
	„ fried, E.P.	4¾ „
	Plaice, A.P.	11½ „
	„ fried, E.P.	5¾ „
	Soft roe, fried	4½ „
	Sole, A.P.	10 „
	„ fried, E.P.	5⅛ „
	„ Lemon, A.P.	8½ „
	„ „ fried, E.P.	6¾ „
	Sprats	8⅛ „
	„ fried, E.P.	4⅝ „
MEAT.	Bacon, back, A.P.	11¼ „
	„ „ fried	4¼ „

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[1] *Criticism and Improvement of Diet*, (1933), H.M. Stat. Office.

Bacon, streaky, A.P.	10 oz.
„ „ fried	4¼ „
Beef, corned, tinned	4⅝ „
„ sirloin, roast, E.P.	3⅞ „
„ steak, lean, raw	5⅜ „
„ „ stewed, E.P.	3⅜ „
„ „ grilled, E.P.	4¾ „
Chicken, A.P.	8¼ „
„ roast, E.P.	3½ „
Ham, smoked, A.P.	9 „
Liver, calf, A.P.	5½ „
„ „ fried	3½ „
Mutton, leg, A.P.	6⅜ „
„ „ boiled, E.P.	4 „
„ „ roast, E.P.	4⅛ „
Pork, leg, A.P.	7⅝ „
„ „ roast, E.P.	4¼ „
MILK.	1 quart

These figures in view of war-time's rations look perhaps large, but compared with the middle-class diet in peace-time, they are not so imposing. All dietitians agree on the need for a pint of milk a day for everyone, and the Ministry of Food has supplied this for all pregnant and nursing women and all children up to five. That is half the day's ration of first-class protein. By the time that a middle-class person has had that, plus an egg and two ounces of bacon for breakfast, and say a grilled herring for lunch (at least ⅓ of the ration), he has had over one ration, and the animal protein at dinner in the evening represents a surplus. It is not astonishing to find that the middle-class animal protein intake is as high as 55 grammes per day. It was surpassed by that of the Army as long ago as 1937 when it was 64 per day. The taking of less than 37 is nearly, but not quite, the hall-mark of poverty, as will be seen on studying the figures in individual and other diets.[1] Taking the individual diets of middle-class males collected by Widdowson,[2] which we have already mentioned, we find that only one of the 63 diets investigated had less than 37 grammes per day (30) and at the upper end of the scale one contained the large amount of 121 grammes. (Expressed as uncooked meat, this would represent about 1¼ lb. steak, or more than a week's ration in war-time!)

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[1] McCance, Widdowson and Verdon-Roe. (1938), *Journ. Hygiene*, **38**, 596. Fry and Myers. (1938), *Public Health*, 358.

[2] Widdowson. (1936), *Journ. Hygiene*, **36**, 269.

The average animal protein intake reached the high level of 67 grammes per day.

We thus see that the figure of 37 grammes is by no means an unreasonably high figure to prescribe as the minimum advisable. Nor was it extravagant of the British Medical Association's Nutrition committee to suggest that the animal protein intake of an unemployed male should be 50 grammes. Even if it be held that there is little scientific basis for the figure 37, it is one which on sociological grounds we should like to see everyone enjoying.

To sum up this section on the adult male's need for total protein we may say that on the average it may be taken as 1 gramme per kilo body weight, though there is evidence that some people can maintain efficiency on less and some apparently seem to need more. The reason that most of us do not take protein equivalent to the wear-and-tear protein loss is possibly because life necessitates a continuous interchange between the amino-acids of the circulation and those of the tissues and this dynamic level of interchange varies from person to person. In most countries, except perhaps Canada, the U.S.A., New Zealand and Australia, it is necessary to insist that some of this protein be first-class protein, i.e. protein of animal origin. About half the total protein, or approximately 37 grammes of animal protein per day, represents a figure below which the first-class protein should not fall.

Adult Women. There is naturally less information concerning the needs of the adult female. There is no reason to believe that the needs of the adult non-pregnant women are proportionally any higher than those of the adult male. In fact as her metabolic plane seems to be lower than the male's it might conceivably be less. None the less the League of Nations put the figure at the same in proportion to the body weight as the males, viz. 1 gramme per kilo body weight, and the National Research Council puts it higher, viz. 60 grammes per 56 kilogrammes or 1·07 grammes per kilo. When we turn to the figures collected for this country (in London and its environs) by McCance and Widdowson[1] we find that the average protein intake has a value of 67·3 which is rather more than 1 gramme per kilo body weight, and that the spread of the figures is great. The maximum (90) is more than three times as great as the minimum (28). First-class protein on the average was well above the figure of 37 grammes, viz. 46·0. Fifteen out of the 63 women took less than 37 grammes, but apart from the one extremely low figure (9) the majority of the low figures were at about the 30 grammes level. No one apparently has made any suggestion concerning the minimal amount of first-class protein necessary for women. If we assume her needs to be 0·83 that of a male the figure would be 30 grammes approximately, if 0·7, then 26 grammes. Only 2 women out of the 63 fall below the 26 level and only 5 below the 30 grammes level. There is little guidance here as to what either the total protein or the first-class protein should be, but at the most only an indication that middle-class women in Great Britain exceed the standards of the League of Nations and the National Research Council, and the highly hypothetical standard for first-class protein. Looking at the frequency diagrams of protein intake by women we see that they, unlike those of the men, do not follow the shape of the Calorie intakes, but whether this has any significance is uncertain.

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[1] McCance and Widdowson. (1936), *Journ. Hygiene*, **36**, 294.

Pregnant and lactating women theoretically need more total protein and more first-class protein than the normal. McCance, Widdowson and Verdon-Roe [1] estimate that the total intake of protein in the later stages of pregnancy should be 90 grammes per day, but in the 120 diets they collected they found that only the well-to-do classes approached this figure with 80 grammes, and the others were by no means so high. These figures were collected before the war of 1939–45. It is to be expected that the activities of the Ministry of Food in subsidizing the consumption of milk in pregnancy and lactation will have improved considerably the low intakes found by McCance and his colleagues among the working classes, and it is to be hoped that this improvement will continue now that the war is over.

The League of Nations put the figure for the first three months of pregnancy at the usual level of 1 gramme per kilo body weight; from the fourth to the ninth month 1·5 is suggested and during lactation 2·0 grammes. The National Research Council put the figure at 85 grammes per day (i.e. 1·5 per kilo) for the last half of pregnancy and at 100 (approximately 1·8 per kilo) during lactation.[2] Until we know much more of the physiology of pregnancy and lactation we must be content with these figures which represent guesses, but perhaps reasonable guesses, concerning the amounts of total proteins required in pregnancy and lactation.

The Protein Needs of Children. Here again we are in as great difficulties in giving even average figures as we were with women. There has been little large-scale work done to discover the actual intake of foods by children, let alone what they ought to take. Up till the present we have had to rely on data for 100 children collected by Holt and Fales and published as long ago as 1921. There is, however, a collection of individual diets of over 1000 children, made in the years before the war, an account of which will be passing through the press at the same time as this edition and to which we have already referred. Children show the same spread of protein consumption as they do of Calories. At any age we may find a child taking an amount of protein (whether first class or no) double that taken by another child in the same age group. There is, in the figures, no guidance concerning the necessary intake of any one child at a particular age, but perhaps the average figures may be allowed to act as a standard of reference, in this country at any rate. They represent what is done on the average by children of educated well-to-do people with no reason to stint money spent on food, and so might reasonably, for the time, take the place of the scales based largely on guesswork.

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[1] McCance, Widdowson and Verdon-Roe. (1938), *Journ. Hygiene* **38**, 596.

[2] Clearly no sudden jump at the fifth month of pregnancy and at full term is intended, but a smooth grading from the lower figure to the higher.

Of course one way to study the protein needs of children would be to observe their rates of growth on different amounts of protein in the diet. This has been done in a small way in the U.S.A. and apparently on a larger scale in the U.S.S.R.[1] And it has been found that with children of $1\frac{5}{12}$ to $1\frac{10}{12}$ years, 2·5 grammes of protein per kilo body weight allows of growth only in the warm part of the year ; 3·5 grammes allows growth in cold weather but not optimal growth. The Russians therefore suggest 4 grammes per kilo body weight for children from 1–3 years of age. The estimates by the League of Nations Commission and the figures coming from the U.S.S.R. are placed side by side in the following table.

ESTIMATES. PROTEIN PER KILO BODY WEIGHT

Age.	League of Nations. (grammes per kilo.)	Russians. (grammes per kilo.)
1 and 2	3·5	4·0
3	3·0	3·8
4	3·0	3·5
5	2·5	3·2
6	2·5	2·95
7	2·5	2·7
8–12	2·5	2·5
13	2·5	2·6
14	2·5	2·6
15	2·0	2·6
16	2·0	2·5
17	1·5	2·0
18	1·5	< 2·0

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[1] See LEITCH and DUCKWORTH. (1937), *Nut. Abs. and Reviews*, 7, 257.

Looking at the table, we observe that the Russians have apparently been more generous, except between 8 and 12, than the League of Nations, and they have emphasized the need for proteins of the adolescents. This is the time of most vigorous growth and it is theoretically the time when the protein intake should be greatest. It is true that the Americans have put the total protein of children from 13–15 well above that of the male adult and of adolescents still higher (viz. 85 and 100 grammes per day) but they nowhere reach the height of the Russian estimates. This is brought out in the calculations of the total protein intakes on the Russian figures per gramme body weight using Woodbury's and Baldwin and Wood's scales of weights of American boys,[1] and as it is more easy to think in terms of total protein than of grammes per kilo body weight they are quoted here side by side with the League of Nations' scale, the American scale and the actual amounts taken by English children. A graph is also given (Fig. 7).

PROTEIN INTAKES, ESTIMATED AND ACTUAL

Age.	Weight.	L.o.N.	Russian.	N.R.C.	Actual.	N.R.C.	Actual.
	Boys (Kg.)	Children.	Children.	Boys.	Boys.	Girls.	Girls.
1	9·75	34	39	40	37	40	38
2	12·00	42	48	40	41	40	42
3	14·30	42·9	54·4	40	49	40	46
4	15·87	47·6	55·5	50	52	50	50
5	17·22	43·1	55·2	50	50	50	49
6	19·95	49·9	58·8	50	55	50	59
7	22·66	56·7	61·3	60	63	60	60
8	24·9	62·3	62·3	60	60	60	59
9	28·3	70·8	70·8	60	68	60	62
10	31·1	77·8	77·8	70	73	70	67
11	34·9	87·3	87·3	70	72	70	64
12	37·6	94·0	94·0	70	76	70	69
13	41·6	104·0	108·0	80	79	80	72
14	47·8	119·5	124·5	85	89	80	77
15	54·4	108·8	136·0	85	100	80	78
16	59·4	118·8	148·5	100	94	75	71
17	62·8	94·2	125·6	100	95	75	73
18	64·8	97·2	129·6	100	97	75	76

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[1] LEITCH and DUCKWORTH. *Op. cit.* There are some slight discrepancies between our recalculation of these figures and those given by Leitch and Duckworth, probably due to the interpretations of the scales of weights.

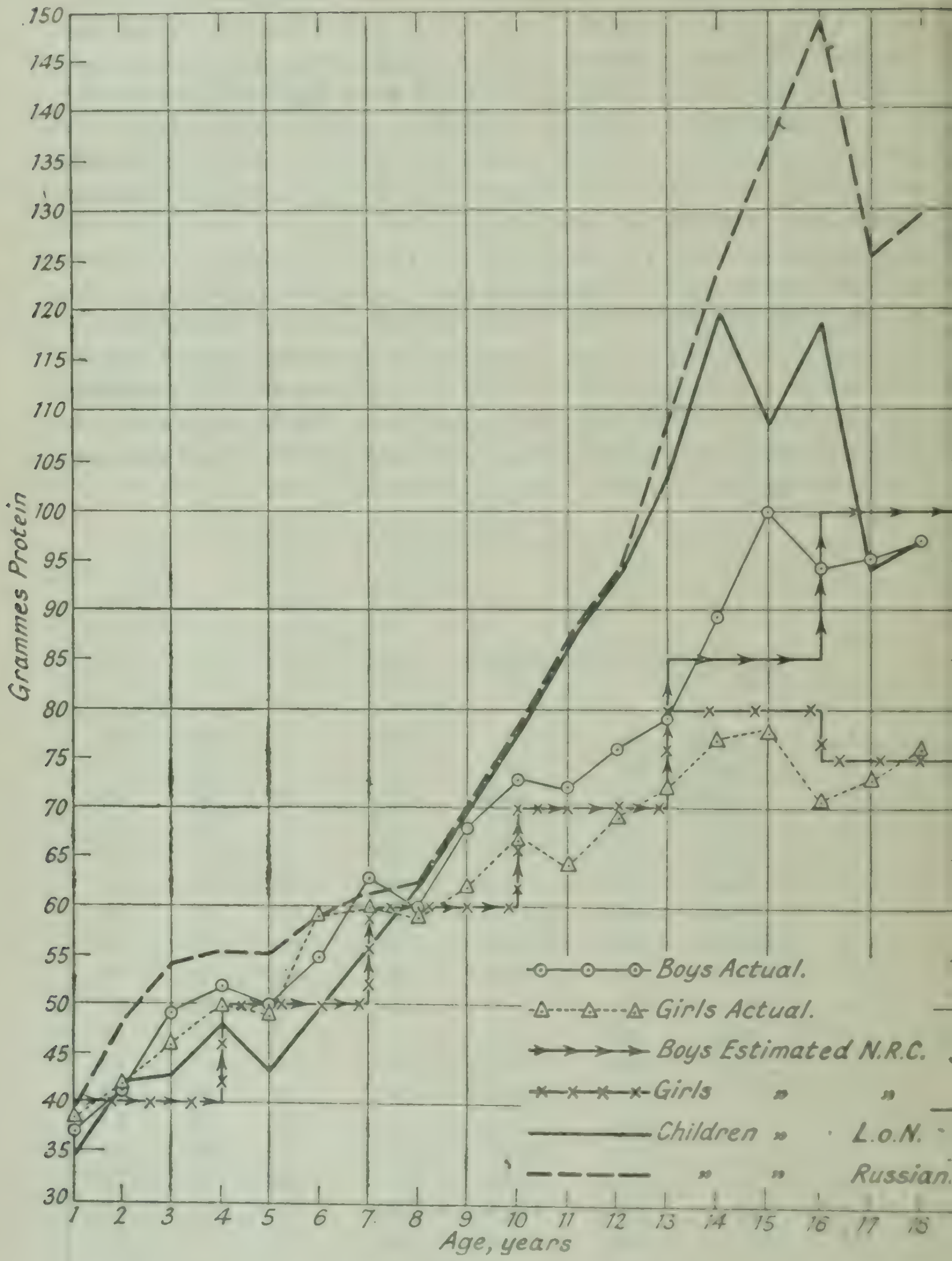

Fig. 7.

The first thing we notice is that the actual intakes of boys and girls of the well-to-do classes in this country run very close to the estimates of the National Research Council of the U.S.A. whereas the Russian and League of Nations estimates are much higher from the age of 10 onwards. The average observer cannot but be impressed by the coincidence of the American estimates and the actual findings among English children, and it may remove some of the inferiority complex over against the U.S.A. from which dietitians in this country quite rightly suffer, to realize that the growth of these English children is up to the Woodbury, and the Baldwin and Wood standards, and that their diet is as good as American dietitians imagine it should be. In fact it might be argued that we are reaching something fundamental here. When growing children in one country take the amounts of foods considered to be necessary by experts on nutrition in a dietetics-conscious nation like the U.S.A. there is a temptation to say that this correspondence indicates an approach to absolute truth. But scientific caution steps in with the consideration that it may be racial make-up and pattern of life which determine the likeness of the food intake of the two countries. It is true that racially the United States is no longer predominantly Anglo-Saxon, nor even Anglo-Celt, and their repertoire of foods is much wider and more interesting than that of Great Britain. None the less, their racial characteristics are predominantly European and their pattern of life more like our own than like other nations.

Turning to minor discrepancies, it will be noted that the intake by boys in this country is *above* the American figures till about the age of 15, and so is the intake by girls until the age of 9. This was to be expected in view of the figures for Calories. With the Anglo-Saxon diet, more particularly middle-class diet, it is usually found that the protein intake runs parallel with the Calorie intake. The English child does his eating early in life and therefore takes protein early. Whether there is any more in this than a reflex of parental solicitude it is for future research to show.

The Calories these English children obtained from protein show but a negligible deviation from 12 per cent. of the total Calories all along the scale from 2 years to 16. This, however, does not indicate any inevitable " rightness " of this proportion but is a reflection of the constancy of the nature of the food eaten. We can, however, take the figures for the protein intake after the curves have been smoothed as a standard with which to compare the dietary protein of children in the future. If their intake is up to this standard then we may accept their diet as satisfactory as regards protein, for the growth of these English children is up to the American standard and we have every reason for believing, both from the esteem in which dietetics is held and practised in the U.S.A. and from what we have seen of their manhood during the war of 1939–45 that America has achieved a sound dietary. If, however, a child's intake is not up to this standard but there be no reason, such as lethargy, pallor or anæmia for assuming that the child is not fit, dietary standards should be forgotten.

We have said nothing so far about first-class protein for children. We have quoted with approval the plea for including some first-class protein in the diet of the adult. How much more is it necessary for children who are continually adding protein to their bodies ? They are not merely replacing " wear-and-tear " losses of protein, but manufacturing new human proteins especially in the first year of life and during adolescence. Theoretically, the growing child (like the convalescent from a wasting illness, the pregnant and lactating woman, and the athlete in training) should have a higher percentage of animal protein in his total protein intake than the adult who has finished growing. Even Terroine,[1] who has stated a case against the academic figure of 37 grammes of animal protein, admits that children need more first-class protein in proportion than adults. He claims, with some considerable support from experimental data, that the biological value of proteins for growth differs from their value for maintenance, and though he pleads for a peasant diet for the adult with only a suspicion of meat and milk to make it palatable, he allows the growing child more of the first-class proteins. Schoenheimer's work on labelled amino-acids points out the particular case of lysine [2] which must be presented to the body preformed. If we argue from this, that that amino-acid is indispensable in the manufacture of protein we emphasize the need for animal protein in the young. There is 6·6 per cent. of lysine in human protein, 7·6 per cent. in the chief protein of milk, 5·0 per cent. in egg protein and only 0·2 and 1·9 per cent. in the proteins of wheat. Therefore the argument suggests that to manufacture human protein rapidly it is much better to use milk and eggs than wheat proteins. In this we completely concur, but the argument can be carried too far.[3]

A child puts on 2 or 3 kilogrammes body weight per year until he reaches puberty. Let us take the higher figure. About $\frac{2}{3}$ of this is water, so the solid material added will be 1 kilogramme. Let us assume that this is all human protein, neglecting the laying down of fat and manufacture of bone. 1000 grammes per year is 2·8 grammes per day. Making the very low estimate of 50 for the biological value of the first-class protein eaten we see that the extra first-class protein needed per day for growth of the child is, on the most extravagant theoretical estimates, but 5·6 grammes a day—the protein to be found in less than $\frac{1}{3}$ of a pint of milk!

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[1] TERROINE. (1936), *League of Nations Quarterly Bulletin.*

[2] The unique position of lysine among amino-acids is brought out by work on its metabolism by NEUBERGER and SANGER. (1944), *Biochem. Journ.*, **38**, 119.

[3] A distinct and significant correlation between the increase in weight for height and the input of foods containing animal protein was seen in 120 children belonging to 63 families observed by BROCKINGTON. (1939), *Public Health*, 209.

In our present state of ignorance about protein metabolism in the young we had better content ourselves with the vague statement that children need more first-class protein in proportion than the adult and urge that the efforts of the Ministries of Food, Agriculture, Health and Education, which have resulted in an increased consumption of milk during the war be continued and further strengthened now that peace is declared. It looks as though the extra needs of children for first-class protein for growth can easily be covered by the pint of milk a day which, in this country, is the goal of dietitians.[1] (In the U.S.A. it is a quart or about $1\frac{5}{7}$ English pints.)

Summing up the paragraphs on the protein needs of children, we see that the estimates of different authorities disagree. Curiously enough the American figures, except at 1 year of age and from 4–6, are the least generous. The Russian figures are the most generous from 1–8 and again during adolescence. Actual data, and not mere estimates, collected by Widdowson in this country of the diets of over 1000 children give results which on the average closely approximate to the American estimates. They are slightly above at most ages except those of adolescence. It is suggested that until we know much more about metabolism in the young we accept the English figures as our frame of reference in this country, rather than "estimates" by however competent people.

Turning to the needs for first-class protein we see that the theoretical needs of children for extra first-class protein for growth when put on a numerical basis are smaller than might be expected and should easily be covered by a pint of milk per day.

Sources of Protein. Before we close this chapter there are a number of practical considerations to be discussed in applying what we know about proteins to dietetics. The first is the source of protein in foods. Very few foods other than sugar and lard and other frying fats are totally devoid of protein. That is obvious from their origin. But that does not mean that we can rely on any food, with those exceptions, for our daily ration of protein. With the exception of milk it is a safe rule to take only those foods which have 10 or more per cent. of protein. If we include foods with less than 10 per cent. as a source of protein we encumber the alimentary tract with much bulk. We smile at an earnest student who proclaims a diet of bread and butter, jam and tea as satisfactory because of the animal protein in the butter, but are guilty at times of a similar mistake. Thus the pulses—dried peas, beans, and lentils—are recommended by many dietitians for their protein content. It is true that uncooked haricot beans have 21·4 per cent. of protein, but they are inedible in that form. When cooked they have but 6·6 per cent. and have far too much bulk to be used as the sole source of protein. To obtain even 37 grammes of protein from cooked pulse we should have to eat about 1¼ lb., and then we should have obtained only 540 Calories.

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[1] Actually the children of the middle classes in England take on the average two-thirds of their protein as first-class protein and at most ages far and away more than the "standard" 37 grammes.

The rule of counting no food a protein food unless it has 10 per cent. of protein excludes all leaf, root, and seed vegetables and all fruits, even though leaf proteins have an excellent biological value (CHIBNALL). It includes eggs (11 per cent.), most fish (9–15 per cent. as purchased), meats (11–17 per cent.), soft cheese (over 20 per cent), and hard cheeses (25–35 per cent.). Cooked fish vary from 17 to 24 per cent. and meats 20 to 32. Pure vegetarians having had the ground thus drastically cut from under them may put in a plea for nuts in which the figures run as high as 31 (pine kernels) and 28 (pea nuts).[1] These can be eaten raw and even when cooked contain a large amount of protein. But we must point out that nuts are not easily digestible, nor are their proteins of good biological value. Unless some unforeseen and radical change occurs in our ideas concerning the amount of protein necessary per day, we shall have to give pride of place to foods of animal origin.

When should the protein foods be taken during the day? We cannot avoid taking some protein at each meal, but should there be a meal in which the emphasis is on protein? It used to be the custom in our public schools many years ago to crowd the animal protein, mainly as meat, into the midday meal, and let breakfast and supper be mainly carbohydrate and fat. This almost certainly involved the waste of a large quantity of Calories due to the specific dynamic action of the protein. If protein is taken in smaller amounts throughout the day the specific dynamic action is not so marked, so that the rule "little and often" with adequate amounts of carbohydrates at the same meals is a practical rule, followed by most people of the well-to-do classes, which has theoretical backing.

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[1] In fairness to the vegetarians it must be said that a high bread diet, coupled with milk, eggs and cheese, is a high protein diet.

We say that carbohydrates should accompany the proteins. This is in flat contradiction to a once fashionable and still prevalent system of diet, which divorced as far as is possible those two proximal principles. Thus potatoes were not to be taken with meat nor bread with cheese, nor, we suppose, " chips " or a white sauce with fish. No meal, on this diet, was to contain meat followed by a farinaceous pudding. The diet was based on a false assumption that an acid medium is necessary for protein digestion and an alkaline medium for carbohydrate digestion.

It should have received its quietus from experiments carried out in 1939 by Cuthbertson and Munro.[1] No carbohydrate was allowed in two of the four daily meals, which consisted of meat and fat only; whereas in the other two meals carbohydrate only was given. (This consisted of cooked corn-starch and sugar.) When such a diet was taken in which the carbohydrate was almost completely divorced from the protein, even though 80 to 100 grammes of protein and Calories from 2700 to 3400 per day were taken, the subjects of the experiment lost *all* the nitrogen of the protein eaten *plus* some extra nitrogen which could have come only from the tissues of the body, probably the muscles. In other words, *protein when divorced from carbohydrate in the diet is of no use in repairing the wear and tear of body protein.* It is of the highest importance that some, at any rate, of the protein in the diet—say one-quarter—should be associated with carbohydrate, otherwise it might as well not be taken.

Confirmation of these experiments have been obtained in work upon animals and in the use of amino-acid mixtures and protein digests in therapy. The latter belongs to Part III of this book, but receives mention here because of its bearing on normal dietary. Amino-acid mixtures and protein digests given either orally or intravenously are of no value in the anabolism of protein unless given concurrently with glucose. They are at once deaminated and the residues used for the production of Calories. Only when glucose is present can they be built up into protein.

The explanation of the results of these interesting experiments given by Cuthbertson and Munro has resolved a problem which must have puzzled physiologists for forty years. Proteins are digested to amino-acids in the small intestine and are absorbed as such into the blood. This blood passes directly to the liver which contains among others potent ferments called deaminases.

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[1] CUTHBERTSON and MUNRO. (1939), *Biochem. Journ.*, 33, 128.

These proceed to eliminate the nitrogen from the amino-acids and therefore make them useless for body building. This appears to be a most ingenious plan for preventing the tissues of the body from ever getting any amino-acid from which to synthesize protein except the ones which the liver had not time to metabolize. In fact it seemed to be a dangerous mechanism. Cuthbertson and Munro suggest that glucose derived from the starchy and sugary foods of the meal depresses the activity of the deaminases, which can only effect their devastating purposes in the absence of carbohydrates from a meal containing protein.

These observations explain the way in which one "reducing" diet works. A simple way of reducing weight is to eat nothing but lean meat and green vegetables. Such a régime was instituted on the grounds that the vegetables would give bulk with but few Calories and so satisfy appetite, and that the high specific dynamic action of the protein would cause the combustion of fat in the body. Probably what happens in this régime is that the protein is used entirely as fuel and the tissues of the body are depleted of their substance. Assuming that the endogenous nitrogen metabolism is 3 grammes per day, this would entail a loss of 18·75 grammes of protein from the body. As each gramme of protein would be accompanied in the body by 4 to 5 grammes of water, the loss of over 18 grammes of protein would entail a loss of body weight 5 to 6 times as great, i.e. about 4 oz. per day or 1¾ lb. per week.

It need hardly be pointed out that if our assumptions are correct the use of such a régime for loss of weight is a dangerous proceeding, for the valuable muscle protein is destroyed instead of useless fat.

We have seen above that there is a case for taking definite amounts of total protein and animal protein per day. Do these bear any fixed ratio to the fats and carbohydrates of the diet? In the past a suggested ratio of 1 : 1 : 4 for these component parts of a diet has crystallized almost into a dogma. We may say at once that there is no evidence from the history of, and observations on, mankind that there is any sacrosanct ratio. The reason for maintaining a diet similar in its protein content to the normal British diet, i.e. one in which the protein yields from 10–12 per cent. of the Calories, is mainly economic. A dense population, and therefore a civilization as we understand it, cannot be maintained upon a high protein diet. It takes many more acres to produce protein than to produce carbohydrate. A dense population first became possible when the value of cereals in diet was realized and exploited. Even dairy farming cannot by itself support so dense a population as wheat farming.

Such considerations make us realize the extraordinary latitude of diet which the human body tolerates. In the days of the cave man, diet must have been predominantly protein; in the more recent days of nomadic existence the diet was still largely protein; in modern times it has swung over to being predominantly carbohydrate. Among different races in modern times the percentage of calories obtained from protein may vary from 40 per cent. (Greenland) to 8·9 per cent. (Java), and while we may consider the latter unduly low, the former is not dangerously high. Even in England, with all the pressure of custom to fix the ratio, it may swing from 8·3 to 19·3.[1] So long as the relation of protein, fat, and carbohydrate is such that the fat in gross amount does not rise above the relation expressed in the equation

$$F = 2C + \frac{P}{2},$$

when ketosis may occur, we may adopt a diet of almost any relation between the main constituents. The most we can say is that if there is an optimum ratio we do not know it yet.

A final point for discussion is whether among the proteins any one has a particular virtue apart from the high biological values of the animal proteins. We are thinking more especially of meat. It holds such a high place of esteem in the minds of most of us from, it is said, a pre-eminent statesman to the man in the street.[2] Meat, it is thought, makes for muscle and energy. By common consent among the working-classes of this country the bread-winner gets the lion's share of the meat. In the now obsolete system of diet of the rowing man, in vogue when the authors were undergraduates, the subjects of the régime were told to eat huge meals of meat and then "work it into the system" by arduous exercise. So far as we can see, there is nothing but prejudice in favour of the view that there is anything which places meat, in so far as the protein it contains, in a position apart from the other protein foods. The reasons for curtailing its consumption are economic rather than dietetic, though there is evidence that meat is contra-indicated in some forms of dyspepsia.

But there is one circumstance in which it is theoretically wise to cut down meat, and other sources of first-class proteins, viz. in hot weather and hot climates, particularly hot climates which

[1] Widdowson. (1936), *Journ. Hygiene*, **36**, 269.

[2] This is by no means confined to the British. According to a manager of tin mines in Nigeria, the natives will do almost anything to obtain meat, even if it be only the flesh of rats and lizards. (Private communication.)

are humid. Animal proteins have a higher specific dynamic action than vegetable proteins ; moreover, most of the sources of animal protein have a fairly high concentration of protein whereas vegetable sources have not. Consequently it is easy to have a surplus of protein at a meal when meat is eaten, but not so easy when vegetarian foods are used, and the specific dynamic action of protein has thus a good chance to show itself when animal protein forms the main part of a meal. The difficulty in hot humid climates is to get rid of this inevitable waste heat and so it might plausibly be argued that meat eating be cut down with advantage in such climates, but on examination this argument is not unassailable.

The lowering of the specific dynamic action of protein in cool surroundings and its raising in warm surroundings was observed in animals. Man by his clothing and by his housing accommodation maintains a tropical climate next to his skin. Consequently the specific dynamic action of protein will have its full effect whether the shade temperature is high or low. None the less it might be well in a hot humid climate to reduce the protein to the minimum necessary and to spread it throughout the day, and not to take it all at one meal. If, however, the nights are cool in a hot climate the concentration of the protein into the evening meal would not matter so much, for the specific dynamic action would not be in evidence till 3 to 6 hours later. To have, however, a large protein meal at midday would involve an outburst of heat in the late afternoon at a time when the thermometer is at its highest.

In view of the fact that proteins supply but about 10–12 per cent. of the Calories of a diet, it might seem that the suggestions in the last paragraph are pushing hypothesis too far. Thus if all the protein of the day's diet were taken at 8 p.m. its maximum specific dynamic action (37 per cent.) would entail a surplus production of 152 Calories. This would probably be evolved from the body between 11 p.m. and 2 a.m., i.e. at the rate of 50 extra Calories per hour. As the normal rate when resting will be above the basal metabolic rate of 70 Calories per hour and below 125 per hour (3000 ÷ 24), the extra Calories due to the specific dynamic action of the protein would cause an increase in the rate of evolution of heat by 40 to 70 per cent. This certainly is a large increase and where there is difficulty in eliminating excess of heat, i.e. where the nights are hot and humid, experience may prove that a heavy protein meal in the evening is unadvisable. It must be admitted that custom in the hot humid climate known to one of us flouts theory.

Summary. As proteins are the main architectural element in living protoplasm and as the body cannot synthesize proteins from simple inorganic substances, proteins are essential in diet for growth and repair of the body. Proteins are complex chains—condensation products—of simpler organic compounds, amino-acids, of which there are twenty or more examples in most proteins. There may be 250 molecules of amino-acids in any protein and therefore some of them must be repeated more than once, indeed many times. Proteins differ from one another according to the number, nature, proportion and arrangement of their constituent amino-acid. Some food proteins are better body builders than others, because the amino-acids composing them are like those of the human tissues in number, nature and proportion. (Arrangement does not matter because before they are used by the body they are digested to their component amino-acids.) Such proteins are said to have a high biological value, and the proteins with high biological value are those of milk, eggs, meat, fish and cheese.

It is therefore considered wise to have some proteins of high biological value in the diet every day. How much is uncertain, but there is a provisional estimate for the adult male of 37 grammes per day. Many did not reach this level during the war 1939–45. How much the total protein should be is also uncertain. Again provisionally it is fixed at 1 gramme per kilo body weight. In practice there are large departures from this suggestion without any disease.

Pregnant and nursing women need more protein than the non-pregnant. The League of Nations estimate is to increase it by one-half in the later days of pregnancy and by 100 per cent. during lactation. American estimates are lower. In practice this is rarely achieved.

Proportionally to their weight children need more protein than adults and theoretically more first-class protein. The estimates given by different groups of dietitians differ markedly from one another, the Russian figures being greatest during the first few years of life and during adolescence. Until the third decade of this century no one has collected data of children's intakes on any large scale and the results prove disconcertingly variable. The average figures for the protein per day collected by McCance and Widdowson are suggested as a scale of reference for children in Great Britain.

CHAPTER IV

THE FUNCTIONS OF FOOD (*continued*). (III) THE SUPPLY OF ELEMENTS OTHER THAN CARBON, HYDROGEN, OXYGEN AND NITROGEN

So far we have dealt mainly with substances in food usually studied by organic chemists—the proteins, fats, and carbohydrates. It is necessary now to turn to the supply of the elements usually studied by inorganic chemists. They are often referred to as the mineral constituents or mineral salts in the diet. This is wrong. Sulphur, for example, enters the blood stream as part of an amino-acid. Sulphur in the form of mineral salts is absorbed with difficulty and excreted unchanged. The cumbrous phrase of the title shows what is meant, but for practical purposes we shall call them mineral or ash elements.

We can best realize their importance by reference to the amounts of these elements which enter into the structure of the body. The calculations here given are from analyses by Sherman.[1] The following amounts of inorganic materials are found in the body of an adult man of 70 kilogrammes weight (= 11 stone approx.) :

Calcium . .	**1050**	**grammes**	**Cobalt** . . .	**a trace**
Phosphorus .	**700**	**„**	**Silicon** . .	**„**
Potassium .	**245**	**„**	**Aluminium** .	**mere traces**
Sulphur . .	**175**	**„**	**Arsenic** . .	**„ „**
Chlorine . .	**105**	**„**	**Boron** . . .	**„ „**
Sodium . .	**105**	**„**	**Copper** . .	**„ „**
Magnesium .	**35**	**„**	**Fluorine** . .	**„ „**
Iron . . .	**2·8**	**„**	**Nickel** . . .	**„ „**
Manganese .	**0·21**	**„**	**Zinc** . . .	**„ „**
Iodine . .	**0·028**	**„**		

It will be seen from this table that at least 19 elements enter into the composition of the body though in very different amounts. It must not be thought, however, that the order of magnitude indicates either the order of their importance or gives a complete clue to the amount necessary in the daily diet. For example, there is much more potassium in the body than sodium, yet we need a much greater intake of sodium than of potassium per day. There is but a small amount of iodine in the body, a trace of cobalt and mere traces of copper and zinc. Without the iodine life would be impossible and there is more than a hint that the "mere traces" of copper and cobalt are essential in the manufacture of hæmoglobin, the red colouring matter of the blood, and of zinc, in the manufacture of insulin and of carbonic anhydrase. It is possible that we could dispense with the traces of aluminium, arsenic, boron, and silicon, though this is by no means proved. Fluorine in minute amounts makes for hard enamel in the teeth.

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[1] R. H. A. and Violet Plimmer. (1938), *Food, Health and Vitamins*. 8th edn. McCollum and associates in *The Newer Knowledge of Nutrition*, 5th edn., put the figure for calcium at 1400 to 2000 grammes.

The functions of these elements are twofold. They enter into the structure of the body and they aid in catalysing the reactions of the living body. Thus the spectacular amounts of calcium and phosphorus given in the table go to make up the solid structure of the bones and teeth, which account for one-fifth of the weight of the body. Iron is an integral part of the colour-bearing nucleus of the hæmoglobin. Phosphorus also enters into the structure of the nuclei of all the cells in the body and into the myelin sheaths of the nerves. Sulphur is present in practically every protein and more particularly in those of the skin. Potassium is an essential part of the cellular elements of the body, e.g. the red blood corpuscles, though there it is probably held in solution and the functions of the blood corpuscles depend partly on their ability to keep potassium inside them and sodium out. Magnesium enters into the composition of the bones, and the muscles and the other soft tissues of the body contain magnesium in greater proportion than they contain calcium. Animals deprived of magnesium suffer from lesions of the bloodvessels and nervous system and a shortage in the diet leads to defective bones and teeth.

These elements may be used for catalytic as well as for structural purposes. Thus traces of ionized calcium salts are essential for the maintenance of the activity of the skeletal, cardiac, and unstriped muscles of the body. So essential is the maintenance of the correct amount in the blood (about 8–10 milligrammes per 100 c.c.) that a set of four glands, the parathyroids, have that function deputed to them. Should there not be sufficient in the food to keep that quantity normal, these glands mobilize calcium from the bones to tide over the emergency, and if the deficit of calcium is long continued a condition of tetany supervenes. If the calcium in the blood serum falls below 4 or 5 milligrammes per 100 c.c. tetany may develop and this is especially likely if the ionizable calcium is reduced. Phosphorus, as phosphates or pyrophosphate, in combination with thiamine and nicotinamide, acts as a catalyst in carbohydrate metabolism and is essential in combination with creatine in initiating muscle contraction. In fact, wherever there is active metabolism in progress the presence of phosphorus as a catalyst is suspected. As a phosphate it is utilized in buffering, i.e. modifying the hydrogen ion concentration of the plasma of the blood and of the red corpuscles. Also it is utilized in the secretion of an acid urine from an alkaline blood plasma. Sulphur in glutathione is important in catalysing oxidation in the tissues. Copper catalyses the manufacture of hæmoglobin and possibly manganese and cobalt aid in this or similar processes. Four iodine atoms are present in thyroxine, a secretion of the thyroid gland, which catalyses the metabolic processes of the body. Thus 5 milligrammes of thyroxine, containing about 3·6 milligrammes of iodine, injected into the body, raise the basal metabolic rate by 40 per cent. Zinc, as we have said, may be essential in formation of insulin, the internal secretion of the pancreas, which catalyses carbohydrate metabolism. Zinc also is a constituent of anhydrase, an enzyme, essential in respiration, found in the red blood corpuscles.

These facts illustrate the enormous importance of obtaining a sufficiency of the various mineral elements in the diet. We must proceed to give an account of the sources of these elements in the food and the amounts of each necessary in the daily diet.

The elements to be considered are the metals calcium, magnesium, potassium, sodium, iron, cobalt, manganese, copper and zinc and the non-metals fluorine, chlorine, iodine, sulphur and phosphorus. Some are needed in large amounts and some only in traces, whence they get the name "trace elements". Among these "trace elements" are cobalt, manganese, copper, zinc, fluorine and iodine. Convenience and not chemical order has dictated the precedence of these substances in the sequel.

Calcium

This element enters into the composition of bones and teeth as the phosphate and carbonate. There is evidence that these two compounds are associated as they are in the mineral apatite. It is absorbed, probably in inorganic form in the small intestine and this absorption is aided by the presence of vitamin D in the diet. How the vitamin works is obscure. It is known that the hydrogen ion concentration of the contents of the small intestine increases in the presence of vitamin D, and this has led to the supposition that to increase the acidity in that organ is the function of that vitamin. Calcium salts are much more soluble in aci media than in alkaline. But that cannot be the only explanation, for calcium in the presence of vitamin D is well absorbed even when the small intestine is rendered alkaline by large doses of alkali.[1] The calcium circulates in the blood, in the plasma of which it is present to the amount of about 10 milligrammes per 100 c.c., and is presumably deposited in the bone and the excess excreted in the urine. The traditional belief that excess of absorbed calcium over the needs of the body is re-excreted into the colon is almost certainly false.[2] All calcium in the fæces is calcium which has failed to be absorbed or has passed into the gut in the digestive juices. Anything which hurries the food along the intestine, such as purgation or the use of large quantities of roughage, is inimical to the absorption of calcium. Meulengracht [3] has described a case of severe depletion of the calcium of the bones (osteoporosis) which he thought was the result of prolonged daily purgation with sulphates. Phytates which form insoluble salts with calcium prevent the absorption of that element.[4] Excess of phosphates and unabsorbed fatty acids, as in cœliac disease, chronic pancreatitis, sprue, and the inborn error of metabolism congenital steatorrhœa, work in that way. If calcium in the food is in the form of a phytate (calcium magnesium inositol hexaphosphate) it will not be absorbed. Calcium oxalate (e.g. in spinach) is not absorbed.[5] While 90–100 per cent. of the calcium of skim milk, and from 80–100 per cent. of that in green leaves of the cabbage and its allies is absorbed, only 15–20 per cent. of that of spinach is available.[5, 6]

To ensure absorption, the diet must contain available calcium, such as that in milk and cheese, and vitamin D must also be present. A low calcium diet is of more use to the body in the presence of vitamin D than a high calcium intake in the absence of that vitamin.

The lack of calcium in the diet leads to osteoporosis of the bones, and the lack of vitamin D to rickets and to osteomalacia, which is almost certainly adult rickets. The power of forming new bone is not confined to the young. According to Roholm, quoted by Leitch,[7] workers who have been forced to leave their employment in a cryolite factory on account of deposition of calcium around the bone show the deposits well organized as normal bone when

[1] Graham and Oakley. (1938), *Arch. Dis. Child.*, I, N.S., p. 1.

[2] McCance and Widdowson. (1939), *Biochem. Journ.*, 33, 523.

[3] *Lancet.* (1938), 2, 774.

[4] McCance and Widdowson. (1942), *Journ. Physiol.*, **101**, 304.

[5] Fairbanks and Mitchell. (1938), *Journ. Nutrit.*, 16, 79.

[6] Kung, Yeh, and Adolph. (1938), *Chin. Journ. Physiol.*, 13, 307.

[7] Leitch. *Nut. Abs. and Rev.* (1937), 6, 553.

examined post-mortem years later. Meulengracht and Meyer, also quoted by Leitch, give examples of men and women verging on old age who were able to manufacture new bone on treatment with calcium and vitamin D. They had suffered for years with "rheumatic pains" which did not yield to treatment till osteomalacia was diagnosed and they were treated for that complaint. It is possible that the fragility of the bones of the aged and some of their "rheumatism" are due to a prolonged deficit in the diet of calcium.[1] The condition called senile or spinal osteoporosis, in which the vertebræ contain much less calcium than usual and are liable to undergo crush fractures, has a different pathology from osteomalacia, since there is no osteoid material present.[2] It cannot therefore be caused by lack of vitamin D and its causation is still unknown, though it seems probable that a long-continued lack of calcium, phosphorus and perhaps vitamin C may be responsible. The final report of the League of Nations Technical Commission on nutrition calls attention to the disappearance of such pains in pregnant women on treatment with calcium and vitamin D. Maxwell,[3] late Professor of Obstetrics and Gynæcology in the University of Peiping, often had to perform Cæsarean-section on women with osteomalacia resulting from lack of calcium and vitamin D in the diet. The babies of these patients also suffered from fœtal rickets. He thought that the intense activity of the fœtus in utero in such women was the result of a tetany due to lack of calcium and vitamin D. The diet of the Chinese is notoriously deficient in calcium. Though European diet is better supplied there is evidence of a deficit. We have as proof the surveys by Orr [4] and Crawford and Broadley [5] and the fact that Stettner [6] finds a very high percentage of the children of the hospital class with osteoporotic bones at all ages, with a minimum at 3 years of age, and that osteoporosis also occurs in middle-class children. Calculations by the students of one of us showed that in war-time and upon war rations it was possible by careful purchase of calcium-containing foods and making use of all priorities to obtain calcium up to the assessed requirements except during adolescence.[1]

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[1] Lyall. (1944), *Proc. Nutr. Soc.*, **1**, **143**.

[2] Burrows and Graham. (1945), *Quart. J. Med.*, N.S. 14, 147.

[3] Maxwell. (1923), *China Med. Journ.*, **37**, 625; (1924-5), *Proc. Roy. Soc. Med.*, **18**, 48; (1925), *Journ. Ost. and Gynæc. Brit. Emp.*, **32**, 433; Maxwell and Turnbull. (1930), *Journ. Path.*, **33**, 327; (1935), *Proc. Roy. Soc. Med.*, **28**, 265.

[4] Orr. (1936), *Food, Health, and Income*. Macmillan & Co.

[5] Crawford and Broadley. (1938), *The People's Food*. Heinemann.

[6] Stettner. (1931), *Zeit. f. Kinderheilk*, **51**, 435, and 1932, **52**, 1. Quoted by Leitch.

There is obvious reason, therefore, for estimating the need for calcium of people of all ages, for it is clear that many people in all parts of the world are in danger of obtaining too little. The minimum amount for maintaining balance of calcium in the adult has been obtained in a similar way to that used for protein. It is not sufficient to take the lowest amount of calcium in the food which just balances the loss of calcium from the body in the excreta, for both positive and negative balances may occur on quite a large or small intake. This is due to mobilization from the bones by extra parathyroid activity or to deposition of calcium in the bones under the influence of vitamin D.

The figure obtained by Leitch [2] is 550 milligrammes per day. If, as seems reasonable, we allow a 50 per cent. margin for safety, we reach a figure of 825 milligrammes per day. There are certainly many people who do not attain that figure, though the average figure in the 63 men investigated by Widdowson was 870. In the women it was 630. It may be that the figure of 825 milligrammes is too high. Sherman suggests 680. But whatever the truth may be we can be sure that our needs for calcium will be easily covered if we increase the consumption of milk in this country to the level the dietitian demands, i.e. at least 1 pint per day. One pint of milk contains 680 milligrammes of calcium.

Pregnancy, in its last three months, entails an increase in calcium consumption on the part of the mother. Otherwise her bones will be depleted to make good the needs of the fœtus when its bones are ossifying. Maxwell gives evidence from his experience in China that earlier pregnancies so deplete the skeleton of the pelvis that in later pregnancies it is deformed and the infants have to be delivered by Cæsarean-section. It is possible that the funnel-shaped pelves seen in this country in multipara of the poorer classes are due to such loss of calcium.

The main work on the calcium needs of women in the last 2½ months of pregnancy we owe to the Toveruds [3] of Oslo. They investigated the calcium of women during that time in a small maternity hospital which preferred to have the mother in hospital throughout that period. Making assumptions based upon analyses of the bones of prematurely still-born children they could, by analysis of the food and the calcium excretion of the mother in the excreta, discover whether their women were in positive or negative calcium balance. At first they could never obtain a positive calcium balance on the diet usually served in the hospital. They then altered the diet, increasing the amounts of milk, cheese, and green vegetables, and adding cod-liver oil in the winter months and still could not obtain a positive calcium balance till they brought pressure to bear upon the women to take the new diet. Then when the calcium intake rose to the high figure of 1·6 grammes per day they were able to establish a positive balance. Such a figure we must therefore take as a requisite for women in the last months of pregnancy. Similar results have been obtained in the United States.[1] One confirmatory piece of evidence is that X-rays showed the bones of the skull and the long bones of the child when born to be better calcified when the mother had had a diet satisfactory in calcium than when she had not. The figure of 1·6 grammes has been accepted by the League of Nations Technical Commission and by most who have investigated the subject.[2]

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[1] TODD. (1934), *Journ. Home Econ.*, **26**, 605, quoted by MCCOLLUM, ORENT-KEILES and DAY. (1939), *The Newer Knowledge of Nutrition*, states that osteoporosis is common in adolescence in the U.S.A.

[2] LEITCH. (1937), *Nut. Abs. and Rev.*, **6**, 533.

[3] KIRSTEN and GUTTORM TOVERUD. (1931), *Acta Pædiatrica*, **32**, Supplement II.

Of the 120 pregnant women investigated in this country one only reached this optimal figure.[3] She belonged to the well-to-do class and owed her high calcium intake (1·75) grammes mainly to the large quantity of milk taken (37½ oz. or nearly 1 quart). 17 took over 1·0 gramme per day and in most cases this was due to a high milk intake. In only one case did cheese partly account for the large amount taken. If the estimate we have accepted be correct, the majority of the women investigated must have been depleting their bones of calcium or would deplete it, according to the stage of pregnancy they were in, if they continued on this régime.

Lactation also involves a strain upon the maternal organism. Assuming a secretion of 1½ litres of milk per day with a calcium content of 0·32 gramme per litre, we get a loss per day of 480 milligrammes of calcium. This plus the normal daily need will demand an intake of at least 1160 milligrammes or a quantity found in about 1½ pints of milk. Should the milk secreted contain still greater amounts of calcium, and figures are quoted by Leitch[1] up to 0·72 grammes per litre, the intake of calcium will have to be still further increased. A quart of milk per day would not cover such an output.

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[1] E.g. in Coons and Hunscher and also by Macy and associates. (1930). See *J. Biol. Chem.*, **86**, 59, and (1931), **90**, 675.

[2] The observations of Graham and Oakley. (1938), *Arch. Dis. Child.*, N.S. I, 1, in cases of renal rickets showed that a positive calcium balance can be obtained with 1 gramme of calcium when large doses of vitamin D—3000 to 6000 I.U. were given. These experiments suggest that it may be unnecessary to give so large an amount of calcium as 1·6 grammes if larger amounts of vitamin D are added to the diet.

[3] McCance, Widdowson, and Verdon-Roe. (1938), *Journ. Hygiene*, **38**, 596.

The ***calcium needs of infants*** can be calculated from a knowledge of the relation of weight of skeleton to the body weight and the calcium content of the skeleton. From the records we have, we gather that a figure of 8 grammes of calcium per kilogramme body weight represents the calcium of the body at birth. To maintain, but not to increase this proportion, the retentions for the first six months of life would be 104, 248, 200, 192, 176, and 135 milligrammes per day respectively at a moderately slow rate of growth. The retentions observed on babies of the working-class quoted by Leitch, are actually below these figures, so that, if the assumptions made are correct, the bones of the babies will be less ossified at six months than at birth. Only if the yields of mother's milk are above 175 c.c. per kilo body weight of the baby and the milk contains over 0·3 per mille. of calcium are the retentions of calcium likely to be enough to cover the baby's needs.

With cow's milk a sufficient retention is more difficult to obtain because though the calcium content is high the curd of cow's milk is difficult to digest. Treatment of the milk with acid or with calcium chloride and feeding it to the baby along with cod-liver oil overcomes the difficulty of digestion and absorption. Iowa pediatricians[2] claim by these means to have obtained retentions in excess of those necessary to maintain the skeleton as well calcified as it is at birth.

Similar calculations can be made for children over the age of one year. We give the figures obtained as a guide to the calcium requirements of boys at different ages. (See next page.)

The figures are compiled from average weights for American children up to 5–6 and thence on from figures for preparatory and public school boys. Until the age of 10 the amounts suggested do not reach the level given by Sherman as desirable. Beyond that age they are much in excess. The greatest increase in height occurs around the 16th year and if the skeleton is to be reasonably ossified it is at that time that the greatest need for a good calcium intake occurs. It will be remembered that Friend, the medical officer of Christ's Hospital, states in his book[3] "that the incidence of broken bones increased remarkably in the rationing years

[1] LEITCH. (1937), *Nut. Abs. and Rev.*, 6, 553.

[2] JEANS. (1933,) *Amer. Journ. Dis. Child*, 44, 69, quoted by Leitch.

[3] *The Schoolboy.* (1935), Heffer & Sons.

	mg. per day		mg. per day
0·5–1	785	9–10	1000
1–2	702	10–11	1267
2–3	734	11–12	1375
3–4	737	12–13	1341
4–5	650	13–14	1494
5–6	849	14–15	1381
6–7	845	15–16	1937
7–8	890	16–17	1841
8–9	841	17–18	1231

1917–1919 and did not fall to normal till 1923." At that time they were having difficulty at the school in supplying sufficient milk. Leitch's figures have been criticized adversely as exaggerations of the truth, but all admit the truth of the trend of the calculations.

We have painted a sufficiently gloomy picture of the attainment or the lack of attainment of the needs for calcium in the diet among several groups of the populace. Figures given by Orr and Crawford and Broadley do not relieve the gloom. Only the wealthiest classes obtain enough and estimates vary from 25 to 35 million out of the 45 million for those whose diet is inadequate. And yet a sufficiency is so easy to obtain! We quote the cheapest conceivable diet: 5 oz. of cheese, 2 lb. $3\frac{1}{5}$ oz. national wheatmeal bread, and 4 oz. cabbage. This diet contains 1084 milligrammes of calcium, assuming that none of the calcium of the bread is available. The diet of a vegetarian who kept a complete record of the weight of all his food during the course of a week yielded no less than 2310 milligrammes of calcium.[1] And in view of the foods which contain plenty of calcium—relatively cheap foods—there is little need that any but the poorest strata of society should go without their quota.[2]

Distribution of Calcium in Foods. *Meat* is of little value, the only exception being tripe, which has been dressed with lime (127 milligrammes per 100 grammes). *Fish* frequently contain large amounts of calcium, especially those in which one can or is forced to eat the backbone. *Milk* and its various products contain large amounts. Contrary to current dietetic superstition *vegetables* and *fruits* contain almost useless amounts.[3] *Brown bread* is extremely poor and probably a good percentage is unavailable; *white bread* has less but probably it is all available.[1] (The problem of the milling of flour will be considered later.) Should a person drink one quart of water with the hardness of London water (17 grains per gallon) he would obtain 243 milligrammes calcium, no mean amount. But if the water had been boiled previously, as in the making of tea, some of the calcium would have been precipitated. Vegetables boiled in hard water actually increase their quantity of calcium because boiling the water precipitates the calcium and the vegetables form a convenient nucleus upon which it can be precipitated. Soft water, like that of Liverpool, is useless in supplying calcium.

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[1] WIDDOWSON. (1936), *Journ. Hygiene*, **36**, 269.

[2] But see note above, p. 105, on the difficulty of obtaining calcium upon war rations.

[3] Figures from M.R.C. Special Report 235. McCance and Widdowson.

The practical politics of obtaining sufficient calcium is easy; it is to increase the intake of milk and cheese. McCance and Widdowson in various dietary studies have shown a close correlation between total calcium and milk intakes.

They further state[2] that wholemeal bread so depresses the calcium uptake by the body that wholemeal flour should be fortified with 200 milligrammes calcium to every 100 grammes flour and 85 per cent. flour with 120 milligrammes. The eating of 1 lb. of unfortified wholemeal bread needs the consumption of an extra $\frac{9}{10}$ pint of milk to balance its adverse effect on absorption of calcium. This emphasizes the need of extra milk, or cheese, in maintaining the calcium balance, especially when whole cereals are eaten, as in many "advanced" diets. There is evidence of decalcification of the bones following a consumption of bread made from a flour of 95–96 per cent. extraction in South Africa[3] and of rickets produced by 100 per cent. extraction from Eire.[4]

CALCIUM CONTENTS OF FOODS IN MILLIGRAMMES PER 100 GRAMMES

CEREALS AND CEREAL PRODUCTS.[5]

Bread, Brown	18
National wheatmeal fortified with calcium	57
Wholemeal	25
Flour, English, 70 per cent. unfortified	19
Manitoba, „ „ „ „	13
Macaroni	26

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[1] There is but little phytate in white flour.

[2] McCANCE and WIDDOWSON. (1942), *Journ. Physiol.*, **101**, 44.

[3] MEYER, OOSTHUIZEN and SHAPIRO. (1942), *Lancet*, **2**, 639.

[4] PRINGLE, REYNOLDS and JESSOP. (1943), *J. Med. Ass. Eire* and CROASDAILE, COLLIS, PRINGLE and JESSOP. *Ibid.* June, 67, 69.

[5] With the exception of the white flours and rice these amounts of calcium are probably unavailable.

	Oatmeal	55
	Rice	4
	Breakfast foods	26–98
FISH.	Dabs, fried	130
	Haddock, ,,	114
	Smelts, ,,	686[1]
	Sprats, ,,	707[1]
	Whitebait ,,	859
	Cockles	All above 110
	Mussels	
	Oysters	
	Prawns	
	Scallops	
	Winkles	
FRUIT, Fresh.	All except blackberries and black currants, from 4–44.	
Dried.	Currants	95
	Dates	68
	Figs	284
	Prunes	38
	Raisins	61
	Sultanas	52
MEAT.	Bacon, raw	7–14
	Beef, various cuts	4–10 (Silverside boiled, 23)
	Ham, raw	14
	Liver	8–9
	Mutton, raw	13
	Pork, roast leg	5
	Sweetbreads	14
	Tripe	127
	Veal, raw	8
MILK AND MILK PRODUCTS.		
	Butter	15
	Cheese (Cheddar type)	810
	Milk, whole, fresh	120
	,, skimmed, fresh	124
	,, condensed, sweetened	290
	,, ,, unsweetened	294
	,, powder, whole	895
	,, ,, skimmed	1225

VEGETABLES.

Beans, runner	33	Chips	14
Beetroot	32	Kale	200
Brussels sprouts	27	Leeks	51
Cabbage	65	Lettuce	26
Carrots	48	Onions	31

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[1] The backbone must be eaten to obtain this amount.

Potatoes	8	Turnips	59
Radishes	44	Turnip tops, boiled	98
Swedes	56	Watercress	222

Note.—Spinach (595) and Rhubarb (103) have been omitted from the above tables because it is almost certain that their calcium is rendered unavailable by the oxalates present.

Phosphorus

We have seen that phosphorus appears in many parts of the body both in its framework and structural units and as a catalytic and a buffering agent. Its use in the latter capacity in the urine results in a loss to the body of approximately ¾ gramme of phosphorus per day. That at least must be made up. In fact there is a demand for phosphorus in foods at least as high as, or higher than that for, calcium. In the adult, if phosphorus be lacking in the diet, the body can draw upon its apatite quarry of the bones for the lacking element; in growing animals this is not possible and a low phosphorus intake limits growth. There is an optimal relation between calcium and phosphorus in the diet which is about 1 : 1 or possibly 1 : 1·5. It is known that in rats a high calcium : low phosphorus and a low calcium : high phosphorus ratio both limit the rate of growth and, in the absence of vitamin D, conduce to rickets. In milk the ratio of Ca : P is as 1·27 : 1. Most text books accept Sherman's suggestions for a reasonable intake of calcium and phosphorus which lead to a ratio of Ca : P of 1 : 1·94, but there is no evidence of what is the optimal ratio. Let us assume at the present it is 1 : 1, that is to say that if the adult man needs 680 milligrammes per day, the non-pregnant woman needs 476 (i.e. 0·7 of the male need); the pregnant woman up to 1474 at the end of pregnancy and growing children from 785 to 1937.

Now there are parts of the world where phosphorus is deficient, e.g. South Africa, and there is evidence of phosphorus deficiency among farm animals in all parts of the world. But the human diets investigated reach even the high estimates of phosphorus need by the League of Nations Technical Commission which are higher than those suggested here. Consequently there need be little trouble concerning phosphorus intakes. It is almost certainly true that if the *calcium in the diet is adequate the phosphorus will be adequate too.* That is because milk, cheese, and the fish, which we take for their calcium, have a high phosphorus content as well.

This raises the question: In what form does the body obtain its phosphorus? It is certainly mainly, but not entirely, in organic combination. Half the phosphorus in milk is in combination with the protein caseinogen. The vitellin of egg-yolk also has phosphorus as an integral part of its molecule. Again in the nucleoproteins it is in combination. Possibly in meats the creatine phosphate, the compound of riboflavin and phosphoric acid, and the adenyl pyrophosphate are all hydrolysed during digestion so that the phosphates are free and uncombined. Anyhow we know that the phosphoric acid is freed by digestion from the caseinogen and vitelline, where it is in combination with the amino-acid serine. And we know that a young growing animal can obtain all the phosphorus it needs from inorganic phosphates. Consequently we assume that phosphorus enters the blood-stream as a phosphate.

One organic compound of phosphorus is found in cereals, pulses, and nuts and to a less extent in vegetables: calcium magnesium inositol hexaphosphate. There is evidence that this is of little or no value in nutrition, for man possesses no ferment, such as plants and rats possess, which hydrolyses the phytates. This shows that we must not accept the phosphorus contents of those foods as all available, nor indeed their calcium and magnesium contents. We must subtract from the total the phytate phosphorus [1] (see below).

Turning to the actual intakes by middle-class people we find that all the men investigated obtained enough available phosphorus [2]; so do most of the non-pregnant women, though there was one out of the 63 consuming considerably less.[3] Amongst the pregnant women [4] there were few up to the standard that we have set, and all those who achieved it had plenty of money to spend on foods. The rest were moderately poor, or had unemployed husbands.

Distribution of Phosphorus in Foods. Milk and milk products have large amounts, and so have eggs. Meat and fish have moderately high amounts. Cereals and pulses have less available phosphorus and fruits and vegetables minimal amounts. Below are given some tables in illustration of this.

Amounts of Phosphorus in milligrammes per 100 grammes Food

Dairy Foods.	Cheese, hard	544
	,, soft	481
	Milk, fresh, whole . . .	94–101
	,, skimmed	98–105
	,, whole, evaporated, unsweetened	254

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[1] McCance and Widdowson. (1935), *Bioch. Journ.*, 29, 2694.

[2] Widdowson. (1936), *Journ. Hygiene*, 36, 269.

[3] Widdowson and McCance. (1936), *ibid.*, 36, 293.

[4] McCance, Widdowson and Verdon-Roe. (1938), *ibid.*, 38, 596.

DAIRY FOODS.	Milk, whole, condensed, sweetened	238
	,, skimmed, condensed, sweetened	270
	Egg, per egg	124
MEATS.	Beefsteak, raw	276
	,, grilled	303
	Kidney, sheep, raw	254
	,, ,, fried	433
	Mutton chop, lean, raw	195
	,, ,, grilled, excluding fat	239
	Veal fillet, raw	258
	,, cutlet, fried	283
FISH.	Haddock, fillets, raw	216
	,, ,, fried	247
	,, smoked, steamed	248
	Herring, fillets, raw	272
	,, (flesh), fried	339
	Kipper, baked	426
FRESH FRUITS.	Apples, English eating	8·5
	Currants, black	43
	Gooseberries, ripe	19
	Raspberries	29
	Strawberries	23
	Tomatoes	21
DRIED FRUITS.	Currants	40
	Dates	55
	Figs	92
	Prunes	83
	Raisins	33
	Sultanas	95

COOKED VEGETABLES. All range from about 29–90.

As we have said above, compounds of phytic acid are often present in cereals and vegetable products usually in the form of calcium magnesium inositol hexaphosphate. Unless these foods contain phytase and in process of cooking this phytase gets a chance to work [1] (as to some extent it does in bread-making) most of the phosphorus of the phytates is unavailable to the body. This not only is a deprivation in itself but, in addition, as we have said in the previous section, the phytates blanket calcium from any source. Consequently the presence of phytate phosphorus in a food is a serious consideration. Below is a table giving figures for phytate and non-phytate phosphorus in foods based on McCance and Widdowson's figures for English foods.[2]

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[1] McCANCE and WIDDOWSON. (1944), *Nature*, **153**, 650.

[2] McCANCE and WIDDOWSON. (1942), *Med. Res. Counc. Report*, 235.

	Total Phosphorus. mg./100 g.	Phytate Phosphorus. mg./100 g.	Non-phytate Phosphorus. mg./100 g.
CEREALS.			
Bread, White, 70–72 per cent. extraction	73	11	62
„ National Wheatmeal, 85 per cent. extraction	142	43	99
„ Wholemeal, 92 per cent. extraction	179	100	79
Flour, White, 70–72 per cent. extraction	102	31	71
„ National Wheatmeal, 85 per cent. extraction	206	113	193
„ Wholemeal, 92 per cent. extraction	287	201	86
Oatmeal	380	266	114
Tapioca	30	0	30
VEGETABLES.			
Beans, butter, raw	318	267	51
„ haricot, raw	309	225	84
Lentils	242	123	119
Peas, dried	303	242	61
„ split	268	152	116
PROPRIETARY CEREALS.			
All-Bran	815	620	195
Cornflakes	58	15	43
Ryvita	295	159	136
Shredded Wheat	287	230	57
Vita-weat	372	220	152
NUTS.			
Almonds	442	362	80
Brazils	592	510	82
Chestnuts	74	13	61
Cobnuts	229	185	44
Peanuts	365	208	157
Walnuts	510	214	296

It is extraordinary how little support the enthusiasts for whole and laxative cereals and for vegetarian substitutes for sources of animal protein get from these tables, though they were not compiled with any other motive than displaying facts, concerning available calcium and phosphorous in the diet.

Iron

That a regular absorption of iron from the food is essential is a platitude, but the problem of how much per day and in what form is still extremely undecided. Two important considerations have recently unsettled any decision. The first is that we are uncertain whether the iron in food must be in an ionized form if it is to be absorbed. For years it has been known that the iron of hæmoglobin is ill digested and ill absorbed. Moreover, foods which, on the analysis of their ash, have abundant iron, do not yield this up to the body any better than foods which have less. Thus spinach which has 4 milligrammes per 100 grammes is no better in the treatment of an artificially produced anæmia than tomatoes which have 0·43 milligrammes.[1] So that before we dogmatize as to which food is "good" for iron and which not we must learn the actual availability in biological experiment.

Secondly, the old assumption that iron can be excreted from the blood into the large intestine has been vigorously questioned and to our minds rightly so.[2] Any iron the body absorbs, it retains tenaciously. It does not necessarily use it to manufacture hæmoglobin. In fact the retentions may be as much as twice the iron already in the blood-stream in the red corpuscles, and though the hæmoglobin may increase in amount it is not increased in proportion to the iron absorbed.[3] The iron is presumably stored in the reticulo-endothelium of liver and spleen, where it can lie *perdu* until it is needed. If this be true it upsets the arguments from most iron balance experiments. It is conceivable that a person should remain in apparent iron equilibrium on a diet containing practically no iron. The small losses from shed epithelial cells and in secretions could be made good from the stored iron. To estimate the normal need of iron in the diet from the results of a number of iron balance experiments would be wrong unless we know that the subjects of the experiment have no iron secreted about their persons.

The history of our iron stores is probably as follows. We are born with from 266 to 937 milligrammes of iron [4] and on an average

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[1] The figures here given are for English vegetables from McCance and Widdowson. (1942), *Med. Res. Council Report*, no. 235, but the experiments quoted were by Tisdall, Drake, Summerfeldt, and Jackson. (1937), *Journ. Pæd.*, **2**, 374. Their vegetables were nearer together in their content of iron.

[2] McCance and Widdowson. (1937), *Lancet*, **2**, 680.

[3] Widdowson and McCance. (1937), *Bioch. Journ.*, **31**, 2029.

[4] Coons, quoted by McCance, Widdowson, and Verdon-Roe. (1938), *Journ. Hygiene*, **38**, 596.

400 milligrammes. This is mainly present as hæmoglobin in the red blood corpuscles and there is excess of it. The hæmoglobin level of new born baby's blood is 145 per cent. (Normal is taken as 100, which corresponds to 13·8 grammes hæmoglobin or 42·1 milligrammes iron per 100 c.c. blood.) The red blood corpuscles in excess of needs at birth are promptly disrupted and the hæmoglobin level falls. The iron from the disrupted blood corpuscles is retained and is doubtless used little by little to form more hæmoglobin as we grow. For the first six months of life we obtain very little iron in our food. Human milk contains but a small amount and cow's milk less. The hæmoglobin may fall to 70 per cent. in breast-fed babies and to as low as 40 per cent. in artificially fed babies.[1] This fall may be prevented in the artificially fed babies by combining iron with the milk fed. When this is done the morbidity rate is greatly lessened, so the fall must be considered pathological. There is evidence that if the mother is anæmic, though the baby may start with a high hæmoglobin figure, its stores of iron are low and the ultimate hæmoglobin level is lower than normal. From the time when the baby gets on to solid foods containing iron the hæmoglobin rises and should become normal, although it is usual in poorer neighbourhoods to discover a low level till the child has reached the age of 3 or 4 years. The hæmoglobin level is determined by the amount of available iron in the food. After puberty there is a drain upon the iron of the body in girls at the monthly periods which may be reckoned at about 40 milligrammes of iron per period, though lower figures are recorded. If insufficient iron is taken in the food, the hæmoglobin level sinks. As a result it is common to find figures for women at the 70–80 level and a level of 90 is considered normal This figure can be raised by iron medication (100 milligrammes per day) by as much as 10 per cent.[2] The usual level of 100 for the male is usually not so raised but there are exceptions.[3] For example, one man with the high figure of 116 had this raised by 10 per cent on taking 1000 milligrammes of iron spread over 46 days. A similar increase of as much as 20 per cent occurred in one of us (V.H.M.) following an intake of 65 milligrammes per day for two months. The figures for the hæmoglobin of American males is often between 110 and 120. These results suggest that possibly both men and women do not get enough iron in their diet in this country.

The pregnant woman has a still further drain on her iron, for though the amount of iron representing the suppressed periods is saved, she hands over some 400 milligrammes to the fœtus, and another 500 milligrammes to the placenta and may lose considerable iron in addition at parturition. Pregnancy and childbirth make for anæmia, as is shown by investigations upon women in our poorer districts. Men on a diet similar to that which results in anæmia in women can achieve a normal hæmoglobin level unless there be loss of blood owing to hæmorrhage.

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[1] MacKay, Goodfellow, and Bradford Hill. (1931), *Med. Res. Council Report*, No. 157.

[2] Widdowson and McCance. (1936), *Journ. Hygiene*, 36, 13.

[3] Widdowson and McCance. (1937), *Bioch. Journ.*, 31, 2029.

It all comes to this: that our source of iron is in food and that the intake should be adjusted so that we have an excess over what is necessary to keep the hæmoglobin level at its optimal figure. What that is, we do not yet know, but it may be taken, in want of further evidence, at 100–110. As the foods which contain iron are few and there is rarely much in them and not all is available it might be well to consider taking medicinal iron in emergencies and, at any rate, to ensure a good store of iron in pregnancy by high iron feeding.

Estimates for desirable iron intake are 15 milligrammes total iron (Sherman) for the adult male and female and 20 milligrammes per day for the pregnant female (McCance, Widdowson, and Verdon-Roe). The National Research Council of the U.S.A. gives the more modest figures of 12 and 15 milligrammes respectively. Children, this Council estimates, need 6 rising to 12, with 15 to cover the years of adolescence. The average intake for 63 men investigated by Widdowson and McCance was 16·8 and for the women it was 11·8 milligrammes, of which 10·8 and 7·9 respectively were "available." For pregnant women the figures run from 14·8 milligrammes (10·3 "available") in the more well-to-do to 8·6 (6·4 "available") in the poorest class. Clearly if the estimates given above are well-founded there is a grave deficit of intake in the women, pregnant and non-pregnant.

Distribution of Iron in Foods. The following table gives the iron content in milligrammes per 100 grammes of food.[1]

Fruits, Fresh.	Cranberries	1·11
	Currants, black	1·27
	,, red	1·22
	Loganberries	1·37
	Raspberries	1·21
Fruits, Dried.	Apricots	4·09
	Currants	1·82
	Dates	1·38[2]
	Figs	4·17

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[1] The figures are mainly from McCance and Widdowson. (1942), *Med. Res. Council Rep.*, No. 235.

[2] Weighed with stones.

Fruits, Dried.	Peaches	6·75
	Prunes	2·41 [1]
	Raisins	1·55
	Sultanas	1·82
Nuts.[2]	Almonds	4·23
	Barcelonas	2·97
	Brazils	2·82
	Cob	1·06
	Coconut	2·08
	Peanut	2·04
	Walnuts	2·35
Raw Vegetables.	Endive	2·77
	Mustard and Cress	4·54
	Peas, green	1·88
	Radishes	1·88
	Spring Onions	1·24
	Watercress	1·62
Cooked Vegetables.	Baked Beans	2·05
	Broccoli tops	1·52
	Butter Beans [3]	1·67
	Haricot Beans [3]	2·50
	Leeks	2·00
	Lentils [3]	2·20
	Peas, dried [3]	1·44
	,, green	1·22
	,, split [3]	1·74
	,, tinned	1·87
	Salsify	1·23
	Spring greens	1·33
	Turnip tops	3·08
Cereals.[3]	Barley	3·6
	Bread, brown	2·7
	,, white	1·0
	Cornflour	1·5
	Oatmeal	3·8
	Rice, brown	2·0
	,, white	1·5
Sundries.	Fried mushrooms	1·25
	,, chips	1·35
	Eggs, per egg	1·58

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[1] Weighed with stones.

[2] Kernels only. Probably the phytates of nuts render this iron unavailable and iron from other foods as well. Widdowson and McCance. (1942), *Lancet*, **1**, 588.

[3] It is doubtful if the iron is available in pulses, the whole cereals and the proprietary cereals. Widdowson and McCance. (1942), *Lancet*, **1**, 588.

SUNDRIES.	Kidney, ox, stewed	7·1
	„ sheep, fried	7·9
	Liver	5·2–6·9

Shell-fish have a high iron content, cockles, mussels, oysters, and winkles having from 15 to 26 milligrammes. It is not known if this iron is available.

The iron contents of some of the proprietary cereal foods are here given.[1]

	mg. per 100 grammes.		mg. per 100 grammes.
Force	3·98	Ryvita	3·73
Grape Nuts	5·64	Shredded Wheat	4·48
Kellog's All Bran	10·8	Vitaweat	3·40
Post Toasties	1·67		

A few figures for meat and fish are included, although much of the iron may be unavailable. (Hæmoglobin is indigestible.)

Bacon, raw	0·92	Herring, fried	1·87
„ fried	2·79	Kidney, fried	7·93
Beefsteak, raw	4·30	Mutton, roast	4·35
„ topside, roast	8·88	Plaice, steamed	0·60
Bloater, fried	1·62	Pork, roast	2·22
Chicken, roast	2·61	Rabbit, stewed	1·90
Haddock, smoked, steamed	0·99	Salmon, steamed	0·81
Ham, lean, boiled	2·61	Sole, fried	1·42

It is unfortunate that we cannot wholly rely on these tables as a guide to obtaining the requisite amount of iron. It has been shown that the iron enters the blood-stream probably in the form of ferrous salts, and not in organic combination as was once thought. One such organic combination is the phytate. Iron phytate is particularly insoluble. Consequently the phytates of whole cereals, bread and biscuits made from them, blanket the iron in these cereals and possibly also some of the iron in the rest of the food. Only animals which have a phytase in their gut can avail themselves of the iron of the whole cereals, nuts and pulses. Now man has no phytase, while the rat has. It was therefore unfortunate that the rat was the animal in which the blood regenerating power of whole cereals was demonstrated. McCance and Widdowson have shown that in man the *use of wholemeal bread depresses the amount of iron absorbed from the food*,[2] probably as the result of the phytates it contains. People in the past who ate white bread may have been anæmic, but probably would have been still more anæmic if they had eaten wholemeal bread.

We are, however, fairly certain of the value of liver, kidney, eggs, the greens (except spinach), dried fruits and treacle. Chappell,[1] working with McCance and Widdowson, has shown that using ordinary, and not stainless steel, knives, in the preparation of vegetables and chipped enamelled saucepans with the iron basis exposed, notably increases the iron content of the cooked food. Presumably all this iron is available. So this observation suggests that we put a premium upon rusty iron knives and saucepans in our culinary work rather than on stainless steel and aluminium modern kitchen equipment. If patients need more iron it is best to give it as some iron salt (e.g. ferrous sulphate) to restore them rapidly to normal.

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[1] *ibid.*

[2] McCANCE and WIDDOWSON. *op. cit.*

Iodine

This element is necessary, but in very small amounts. It has been estimated that as little as 14γ (fourteen thousandths of a milligramme) per day is sufficient ; other estimates are 45γ for an adult and 150γ for a child and one by Eggenberger of the Canton of Appenzell in Switzerland, where the relation of iodine to goitre has been intensively studied, $1–2\gamma$ per kilogramme body weight ; i.e. 70 to 140γ for the average man and $56–112\gamma$ for the average woman.

Though such small amounts are necessary, there are many parts of the world where too little is obtained. These regions are in England, the Pennines, particularly in North Derbyshire, the Cotswolds, the Mendips ; in Europe the Pyrenees, the Alps ; in Asia, the Caucasus, the Himalayas and the central Asian plateau ; in America, the Rockies and around the Great Lakes. Deficiency results in an overgrowth of the thyroid gland, called " goitre "—" Derbyshire neck " in England. This goitre can usually be relieved by giving salts of iodine or food containing iodine. Around the Great Lakes in North America 35 per cent. of the school children once had enlarged thyroids. This number has now been reduced to 1 per cent. by the addition of potassium iodide in small amounts to their intake. The same is true of Switzerland where the incidence of simple goitre has been enormously reduced (it was endemic) by the use of iodized salt. In the Vorarlberg-Tyrol province in Austria 59 per cent. of the boys and 63 per cent. of the girls had thyroid trouble. This has been reduced to one-tenth and much of the reduction is put to the credit of iodized salt.[1] The reason given for the occurrence of goitre is absence of iodine from the drinking water and from the soil, though there is some evidence that presence of lime in the drinking water antagonizes the effect of the iodine in it. In New Zealand there is a distinct parallelism between the incidence of goitre and the deficiency of iodine in the soil, but in this country the parallelism is not complete.[1]

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[1] *Lancet*, (1939), 1, 1061.

Be that as it may, it is certain that the giving of iodine, either as foods containing iodine or as iodized salt (1 part of iodine in 200,000 sodium chloride), will prevent the occurrence of simple goitre.

The foods which contain iodine are the sea fish and the edible seaweeds. As the thyroid is more active at puberty, during pregnancy and the menopause these are times when especial attention should be given to the provision of fish in the diet. The content of fish is as follows:

	γ per 100 grammes.		γ per 100 grammes.
Cod	120	Oysters	120
Herring	200	Salmon	140
Mussels	190		

Watercress also contains fair amounts and so does the onion if grown on soils with a reasonable amount of iodine, but the amounts compared with that of sea fish and edible seaweeds are very small—in the region of a few γ only per 100 grammes. The immunity of the Japanese to goitre is thought to be due to their consumption of edible seaweed. There is no danger of obtaining an excess of iodine as the result of eating iodine rich foods but there is of course a danger that too much iodine may be taken in the form of iodized chocolates, etc., and it may cause toxic changes to occur in patients with long-standing adenomatous goitres. So far no ill effects have been noticed in Switzerland from the addition of 5 milligrammes of iodine to 1 kilogramme of salt (or 1 in 200,000) as a result of many years' experience. Marine is of opinion that the addition of 10 milligrammes of iodine to 1 kilogramme of salt (1 in 100,000) is the concentration to be preferred because it "takes care" of a wider range of iodine deficiences with no appreciably greater risk. Marine has seen twelve patients who developed toxic changes after using iodized salt, but was able to show that other preparations of iodine had been given at the same time.[2]

Iodine plays a part in two other diseases of the thyroid. In myxœdema where the thyroid is atrophied the iodine content of the blood is very low while in toxic goitre it is considerably raised. The latter condition is greatly benefited by the giving of iodine, but iodized salt does not contain sufficient and it is necessary to give 3 to 4½ grains of iodine a day for 10–14 days before operation.

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[1] Orr. (1931), *Med. Res. Council Rep.*, No. 154.

[2] Marine, D. (1935), "Glandular Physiology and Therapy," *J. Amer. Med. Assoc.*, 356.

Sodium

The study of sodium in the diet has in recent times become important, as the result partly of the effects of the loss of sodium from the body in intense perspiration and partly of the discovery that the cortex of the suprarenal body governs the excretion of sodium salts by the kidney. Some of the symptoms of Addison's disease are almost certainly due to the direct loss of sodium and chlorine from the blood.[1] (The apparent increase in potassium is due to the decrease of the volume of the blood in this disease.) As much as 28 per cent. of the sodium and 33 per cent. of the chlorine may be lost from the blood in Addison's disease. It is almost certain that the loss of the sodium is the operative factor, for other sodium salts can take the place of sodium chloride in alleviating the symptoms.

Loss of sodium, as the result of intense sweating, may produce symptoms very similar to those seen in Addison's disease, viz. muscular weakness, dyspnœa after slight exercise, languor, mental confusion, drowsiness. Stoker's and miner's cramp is now recognized as being due to a loss of sodium from the body which is not replaced unless salted water is taken instead of water or similar beverages. Sweating in hot climates may give rise to unrecognized ill-health, and this may be serious and even fatal. A man may lose 3000–4000 milligrammes of sodium in a day by sweating, as was shown in a series of experiments by McCance and his colleagues, with resulting symptoms closely paralleling those of Addison's disease.[2] Three hours exercise in the sun may result in a loss of sodium chloride in the perspiration equal to a whole day's salt ration.[3] The symptoms of Addison's disease may be aggravated by cutting down the sodium intake and increasing the potassium intake by an exclusively vegetarian diet. "Heat Exhaustion," Type I, with its main symptoms vomiting and cramp, as the result of exposure to desert climate, is due to a loss of sodium and can be obviated or cured by increased salt consumption. In extreme cases intravenous injection of normal physiological saline is advisable.[4]

In normal dietetics there is never any likelihood of a depletion of sodium, for most of us take more than enough in food. But if work or exercise is undertaken in hot surroundings there is a danger of such a depletion. Some persons lose sodium in their perspiration much more readily than others and these, if they undertake arduous work or exercise in hot weather or hot surroundings, should make up their deficit by drinking slightly salted water. A level teaspoonful of common salt to a pint of water, which is approximately " normal saline," forms a convenient drink for replenishing the body's store of sodium in these conditions.

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[1] Loeb, quoted by GRAHAM (1937), *Postgrad. Med. Journ.*, 88. See also HINDS HOWELL (1934), *Lancet*, **1**, 1116.

[2] *Lancet.* (1936), **1**, 823.

[3] DILL, HALL, and EDWARDS. (1938), *Amer. Journ. Physiol.*, **123**, 412.

[4] LADELL, WATERLOO, and FAULKNER HUDSON. (1944), *Lancet*, **2**, 491, 527.

In medicine, when there is a depletion of the stores of sodium by excessive vomiting or diarrhœa, or of course in Addison's disease, saline should be given instead of water for the same reason. In all cases when a " salt-poor " or " salt-free " diet is indicated the effects of depletion of the sodium in the extracellular fluids of the body must be borne in mind. Anchovies, bacon, caviare, cheese, haddock (smoked), ham, kippers, green olives, salt fish and salt pork, and sausages are acceptable as a means of supplying sodium in sodium depletion if saline is disliked.

Potassium

Whereas sodium is the element found in the greater amount in the extracellular fluids of the body, potassium is found in the cells. For example, 320 milligrammes of potassium are found in 100 grammes of muscle, whereas in the plasma of blood there are only 20 milligrammes.[1] Consequently in the building of tissues potassium is needed in the diet. In the course of the day as much as 3 grammes may be lost in the urine and this must be replenished.[2] There is, however, no evidence that anyone suffers a deficit of potassium in the diet, for so many foods are relatively rich in that element. All plant foods, even white bread, contain much potassium ; all animal tissues are likewise good sources and the only foods with really small amounts are butter, cornflour, margarine, suet, tapioca, and (surprisingly) tripe.

It is therefore difficult to avoid obtaining enough potassium and still more difficult to devise a diet low in potassium as is advisable in Addison's disease. Such a diet has to be based on white bread, butter, rice, and vegetables cut in pieces and boiled in a large volume of water, but with care a palatable diet can be prepared.[3]

[1] BEST and TAYLOR. (1937), *The Physiological Basis of Medical Practice.* Baillière, Tindall & Cox.

[2] *ibid.* This figure naturally falls during a fast, but even on the 31st day of a fast the amount excreted is 606 milligrammes, which proves that potassium enters into the metabolic processes of the body and that the excreted potassium in an ordinary diet is not merely " exogenous."

[3] ABRAHAMS and WIDDOWSON. (1937), *Modern Dietary Treatment.* Baillière, Tindall & Cox.

POTASSIUM CONTENTS OF FOODS

		Milligrammes per 100 grammes.
FISH.	Cod, steamed	360
	Haddock, steamed	323
	Plaice, steamed	278
	Turbot, steamed	255
FISH, SMOKED AND PRESERVED.	Bloaters	446
	Kippers, baked	520
	Sardines	433
MEAT, FRESH.	Beefsteak, grilled	368
	Mutton chops, grilled	266
	Pork, roast	308
	Rabbit, stewed	210
MEAT, PRESERVED.	Bacon, fried	517
	Ham, boiled	454
	Beef, salt	288
POULTRY.	Duck, roast	319
	Chicken, roast	381
OFFAL.	Liver, calf, fried	407
	Kidney, sheep, fried	304
	Tripe, stewed	9
EGGS.		134
FRUIT.	Apples	116–23
	Bananas	348
	Grapes	250
	Grape fruit	234
	Orange-juice	179
	Pears	129
	Plums	188
	Strawberries	161
	Tomatoes	288
FRUIT, DRIED.	Currants	708
	Figs	1015
	Prunes	864
NUTS.	Almonds	856
	Brazils	760
	Walnuts	687
VEGETABLES, BOILED	Cabbage	144
	Carrots	87
	Peas	293
	Parsnips	293
	Potatoes	325

Sulphur

Sulphur is the one element apart from carbon, hydrogen, nitrogen, and oxygen which is absorbed into the body almost entirely in the form of an organic compound. It is present in most proteins as the amino-acids methionine or cystine or both and is absorbed into the system in that form. Possibly small amounts of sulphates in solution are absorbed in the foods eaten, but their importance in diet is minimal. The amino-acids mentioned are important not only in the construction of human proteins but also of glutathione, a cell catalyst. Further, the sulphur from them must be used in the synthesis of vitamin B_1. There is sulphur in insulin and in taurocholic acid, one of the acids in bile salts which play an important part in the digestion of fats.

Most of the sulphur in the food when metabolized is converted into a sulphate and excreted in the urine as such, though some is detached as cysteine, or converted into glutathione, thiocyanates, etc. which perform essential functions in the body. Some sulphur-containing amino-acids in the form of protein, are essential in the diet and it is probable that methionine is the main one. In a mixed diet there is little likelihood of a deficiency, for egg albumin, lactalbumin, myosin, ovovitellin, and gliadin, proteins from egg, milk, meat, and cereals, all contain over 1 per cent. of sulphur. It is suggestive that egg albumin and lactalbumin, proteins pre-eminently connected with growth, contain the largest amounts of sulphur, i.e. 1·62 and 1·73 per cent. respectively.[1]

Magnesium

That magnesium is essential to the body is obvious from work on animals such as rats and dogs. Deficient magnesium in the diet leads to marked vaso-dilatation, nervous irritability, convulsions and death (McCollum and associates).[2] Human deficiency is unlikely because magnesium is widely distributed in all foods in small but significant amounts. Omitting the whole cereals, nuts and pulses, where the magnesium is present as phytates and therefore not available, we find double figures in milligrammes of magnesium per 100 grammes in many foods. About 200 milligrammes are excreted per day and it is unlikely that there will ever be a deficiency in the human diet. Any excess of this metal in the form of salts in the diet is absorbed with great difficulty, and excess in the blood is excreted rapidly in the urine.[3]

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[1] Osborne, quoted by Sherman. (1937), *Chemistry of Food and Nutrition*. Macmillan Co.

[2] McCollum, Orent-Keiles and Day. (1939), *The Newer Knowledge of Nutrition*, 161.

[3] McCance and Widdowson. (1939), *Biochem. Journ.*, 33, 523.

Chlorine

Chlorine is an element which is taken into the body almost entirely as a soluble chloride and mainly as the chloride of sodium, or common salt. The majority of people add salt to their food as a condiment in amounts which altogether outweigh that naturally in the food. That this is a matter of taste and not necessity is shown by the fact that the Eskimo does not do so, and it is even possible that the herbivora, about whose desire for "salt licks" so much play has been made, take it for the same reason. That salt is more essential in hot climates than cold has already been mentioned, but it must be realized that this is more for the sodium that it contains than for the chlorine.

The body is tenacious of its chlorides and in chloride starvation it reduces the excretion from the high level of 7 or 8 grammes per day to as low as 0·2. In pneumonia the excretion of chlorides may be suppressed till the crisis is past.

Chloride intake is essential for the production of the hydrochloric acid in the gastric juice, for maintenance of osmotic pressure in the tissue fluids and in enabling the blood to carry carbon dioxide. If it were not for the chloride shift from plasma to red blood corpuscle as the blood becomes venous, the blood could not carry its load of carbon dioxide from the active tissues to the lungs. The presence of normal amounts of chloride in the plasma of the blood is thought to be necessary in keeping the calcium of the plasma ionized, thus preventing tetany.

Chlorides (estimated as chlorine) in foods vary from the trace found in apricots, cherries, plums, and similar fruit to such a high percentage as 4·5 in fried bacon, most of which is added in pickling. As the majority of people add salt to nearly every cooked and uncooked food with the exception of fruit (though Americans are known to take salt with fresh cantaloupe melon) there is no likelihood of any deficit in the diet. There are occasions, however, in dietetics when a salt-poor or a salt-free diet is indicated, in which such foods as bacon, baked beans, corned beef, salt beef, bloater, salt butter and margarine, smoked haddock, kipper, meat extracts, olives, tinned salmon, sardines, sausage, and shellfish are forbidden.[1]

Trace Elements

In the table given on p. 100 some elements are stated as being present in the body as traces and others as mere traces. Taking them in alphabetical order: aluminium, arsenic, boron, cobalt, copper, fluorine, nickel, silicon, zinc, we have to ask ourselves whether they are in the body fortuitously or because they are essential. As some of these elements are found in enzymes and other catalysts of the body and have proved to be essential in animal nutrition in small amounts, and as some other elements in traces are found to be deleterious in nutrition (e.g. selenium and molybdenum) it is usual to study their importance in dietetics under the heading: "trace elements."

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[1] Abrahams and Widdowson. (1937), *Modern Dietary Treatment.* Baillière, Tindall & Cox.

Aluminium. There is no evidence that aluminium is essential nor that even large amounts, far beyond what is obtained through cooking in aluminium pots and pans, or consumption of alum containing baking powders, have any deleterious action.

Antimony is not found in the body but receives mention here because traces arising from the use of cheap enamelled ware have caused poisoning in the past.

Arsenic. Again there is no evidence that mere traces in the diet are essential while it is notorious that even a small amount is a deadly poison. The mere traces are of importance mainly in medical jurisprudence. It is interesting to note that oysters and flat fish often have more arsenic in them than would be allowed by health authorities concerned with arsenic as a contaminant.[1]

Boron is essential to plants (apples, broad beans, sugar beets, sugar cane, wheat) but apparently inessential to animals. Because some people are sensitive to small amounts of boric acid the use of boron containing preservatives is illegal in this country.[2]

Cobalt is undoubtedly important to mammals. Its absence from the soils and herbage has led to veterinary trouble—witness "pining" disease of sheep in Scotland, "coast disease" of sheep in south-east Australia, "enzootic marasmus" of cattle and sheep in West Australia, "bush sickness" and "sheep ailment" in New Zealand, "lake shore sickness" in Michigan, "salt sickness" in Florida and "nakuruitis" in Kenya. Cobalt is probably essential to man, but how much or how little per day is not known. 1 milligramme per day suffices for a cow, so less may be enough for a man. There is no evidence of cobalt shortage in human diet. Cobalt in excess is toxic for rats.

Copper[3] forms an intimate part of the oxygen-carrier hæmocyanin found in lobsters, crayfish and some molluscs and also of sundry oxidizing ferments. It is also essential for the formation of hæmoglobin though it is not included in the hæmoglobin molecule. Copper deficiency in the soil interferes with blossoming and setting seed in plants. It is associated with disease of cattle in Schleswig-Holstein, the "falling disease" of West Australia, with "piglet anæmia" throughout the world and with the "sway back" disease of lambs in limestone (and chalk ?) districts of this country. From this evidence we should expect copper to be essential in human diet, and it has been guessed that we need 2 milligrammes per day.[1] Excess of copper is poisonous, but there is a big gap between the amount which will stave off trouble in animals and the toxic dose. No evidence has been presented that human beings suffer from a deficit of copper, but trouble may be expected in those parts of the world where farm animals show a deficit.

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[1] Green. (1944), *Proc. Nutr. Soc.*, **1**, 177.

[2] This rule was relaxed during the second World War.

[3] For a discussion on trace elements in relation to health see *Proc. Nut. Soc.* (1944), 176–225.

Fluorine, once considered dispensable, has sprung into prominence because of its influence on the teeth.[2] For example, the excellent teeth of the inhabitants of Tristan da Cunha, which have been held in the past to support most systems of dietary, are now claimed to be due to the small, but definite, amount of fluorides in the drinking water of that island. When present in more than 1 part per million in the drinking water, fluorine leads to mottling of the enamel of the teeth (e.g. in Maldon, Essex, where there are 5 p.m.m. in the well-water). Excess of fluorine interferes with bone metabolism in cattle, producing exostoses on long bones and mandibles, a condition seen in those fed, for example, on herbage to leeward of the prevailing wind near a group of brick factories.

It is now guessed that the optimal concentration in drinking water is between 0·3 and 0·5 parts per million and experiments on a large scale are being made in the United States on the influence of fluorine on caries of the teeth. It is hoped by controlled addition of fluorine to the drinking water of a town to stop that particular trouble of civilization.

Manganese. This metal occurs in the body in more than traces. It is essential in the nutrition of birds, but is of less importance with mammals. The few milligrammes thought to be important in human nutrition are provided by the otherwise adequate diet. Manganese in relative large amounts is toxic.

Molybdenum causes disease in farm animals in parts of central Somerset and elsewhere, which can be prevented by ingestion of copper. There is as yet no evidence of an effect on human beings.[3]

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[1] Laverton and Binkley. (1944), *Journ. of Nutr.*, **27**, 43.

[2] See *Lancet*, (1941), **1**, 23, 375, 701 and (1944), **2**, 510.

[3] Fergusson. (1944), *Proc. Soc. Nutr.*, **1**, 215.

Nickel and **Silicon.** These are invariably present in human tissues but there is no evidence that they are essential.

Zinc. As already mentioned, this element is essential in the production of insulin and of carbonic anhydrase,[1] but zinc in small amounts is so widely distributed in food materials that it is doubtful if the human race ever goes short of it.

Acid-Base Equilibrium

When the metallic elements present in food are oxidized in the body they give rise to bases, and when the sulphur and phosphorus of the foods are oxidized they give rise to fixed acids, viz. sulphuric and phosphoric acids. Both the bases and the acids are excreted in the urine, and the reaction of the urine depends on the predominance of one or the other.

In fasting the body is consuming its fats and proteins. The main acid end-product of fat metabolism (carbon dioxide) is eliminated via the lungs and so does not affect the reaction of the urine. The fixed end-products of protein metabolism are acid. Consequently the urine secreted during the night or during a fast is acid because protein is being metabolized then. Similarly the urine is acid when a high protein diet is eaten, for its effect outweighs the alkali-producing effect of fruits and vegetables.[2] The urine will be alkaline on a diet containing much fruit and vegetables.

Given the analysis of a food, its influence on the urine can be, with few exceptions, calculated and the following table has been constructed on those lines.[3]

(Ash from 100 gm. is equivalent to c.c. tenth normal alkali or acid.)

Bacon, average, raw	75 acid
,, back, fried	129 ,,
Bread, white	15 ,,
,, wholemeal	59 ,,
Cheese, Cheddar	54 ,,
Cobnuts	39 ,,
Eggs	162 ,,
Flour, white	74 ,,
Haddock, fresh, steamed	177 ,,
Oatmeal	132 ,,
Peanuts	116 acid
Peas, fresh, boiled	14 ,,
Peas, tinned	29 ,,
Pork, leg, roast	286 ,,
Rice	76 ,,
Sirloin, beef, roast, lean	235 ,,
Steak, sirloin, raw	185 ,,
Steak, fried	173 ,,
,, stewed	289 ,,
Walnuts	54 ,,

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[1] Keilin. (1940), *Bioch. Journ.*, **34**, 1163. It is found also in uricase. Davidson. (1942), *Bioch. Journ.*, **36**, 252.

[2] McClellan and Du Bois. (1930), *Journ. Biol. Chem.* 87, 651. "The total acidity of the urine during the meat diet was increased to 2 to 3 times that of the acidity on mixed diets. . . ."

[3] McCance and Widdowson. (1940), *Med. Res. Council Report* 235. H.M.S.O.

Almonds	183 alkali	Currants, black	88 alkali
Apples	28 „	Lemon-juice	38 „
Bananas	79 „	Lettuce	38 „
Brazil nuts	45 „	Whole milk	27 „
Brussels sprouts	8 „	Skimmed milk	23 „
Butter beans, dried	355 „	Onions, raw	5 „
Cabbage, spring, boiled	14 „	Oranges	61 „
Carrots, raw	90 „	Potatoes, raw	103 „
Cauliflower, boiled	17 „	„ boiled	53 „
Celery, raw	84 „	Prunes, dried	203 „
Chocolate, plain	79 „	Rhubarb	130 „
Cocoa	7 „	Tomatoes	56 „
		Turnips, raw	65 „

Unfortunately, the foods which have a preponderance of basic ions in their ash have been called basic foods and those which have acid ions, acid foods, and this has given an opportunity to various food cranks to evolve ingeniously wrong-headed systems of diet. The table shows how misleading this is. Lemon-juice, orange-juice, and tomatoes are called basic despite their acid taste; whereas meat and bread which are almost neutral to litmus are "acid" foods. Taste and reaction to litmus are not a safe guide.

In the case of such a substance as lemon-juice this needs a little explanation. It tastes acid because of the presence of an acid salt, possibly dihydrogen potassium citrate. The citrate part of the molecule and the hydrogen are oxidized in the body to carbon dioxide and water. The carbon dioxide is eliminated from the body via the lungs, leaving the potassium oxide, a highly basic substance, to be eliminated via the kidneys and to increase the alkalinity of the urine.

The question has arisen whether the "basic" and the "acid" foods should not be balanced in the diet so that the kidneys should not be given the trouble of secreting an acid urine. It is often assumed with but the smallest excuse that the secretion of an acid urine is inimical to the kidney. It can be said that in the normal person it does not matter one whit whether there is a balance between the two sorts of food or not. According to Sherman, one of the foremost explorers of this region of dietetics, the question must be regarded as still an open one in healthy persons. In pathological conditions the balance is often of importance.[1] If the kidney has difficulty in secreting sufficient acid to keep the alkali reserve within the normal limit of 55 to 70 volumes of CO_2 (25–31·5 mille molecules) per 100 volumes of blood, the amount of basic foods in the diet should either be increased or some alkaline salt, e.g. sodium bicarbonate, should be given as a medicine. Similarly, if the kidney is unable to keep the alkali reserve down to the normal limits, the acid foods should be increased or acid salts given by the mouth. In both cases the alkali reserve must be estimated at intervals to make certain that an adequate dose of alkali or acid has been given.

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[1] GRAHAM, G., and OAKLEY, W. G. (1938), *Arch. Dis. Child.*, N.S. 1, 1.

It is also claimed that cystine stones in the pelvis of the kidney can be dissolved by giving foods with an alkaline ash,[1] but phosphatic stones cannot be dissolved by the use of foods with an acid ash.

While on this subject of the acidity of foods it would be well to ask whether any of the acids which occur in fruits and vegetables appear unoxidized in the urine. The answer is complicated by the fact that two of them, oxalic and citric acids, are almost certainly formed in intermediate processes of metabolism. There is a normal excretion of 200–1200 milligrammes per day of citric acid, 100–1500 of hippuric acid, and 10–50 of oxalic acid.[2] The acids of fruits are malic (apples, plums, quinces, tomatoes, etc.) ; citric (citrous fruits, pineapple, tomato, and most summer fruits) ; benzoic (cranberry and bilberry) ; tartaric (grape) ; oxalic (strawberries, unripe tomatoes, rhubarb, spinach, and sorrel). The body seems to oxidize malic and citric acid nearly completely ; tartaric is hardly absorbed at all ; oxalic may be absorbed and oxidized or excreted in the urine ; benzoic acid is excreted as hippuric acid. Consequently the foods which concern us as regards acid-base equilibrium are the foods which contain oxalic and benzoic acids.

It is often alleged that when rhubarb and spinach are eaten oxalates are excreted in the urine (oxaluria). It is even further stated that eating the leaves of rhubarb as "greens" during the first World War caused fatal cases of poisoning. There is certainly oxalic acid in the leaves[3] (0·30–1·11 per cent.) and in the stalk from 0·44 to 0·99, and it is possible that if the oxalic acid is present as calcium oxalate, boiling with soda to preserve the colour might transform some of the insoluble and safe oxalate into sodium oxalate, which is poisonous. Leafy vegetables from the spinach family (polygonaceæ) contain oxalic acid mainly as calcium oxalate. The figures for spinach vary from 0·29[3] to 0·93,[4] beet leaves

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[1] Higgins. (1940), quoted in *Lancet*, **1**, 82.

[2] Sherman. (1937), *Chemistry of Food and Nutrition*. Macmillan & Co.

[3] Most of the figures quoted are from Winton. (1935), *Structure and Composition of Foods*, vol. 2. John Wiley & Sons.

[4] Yeh and Adolph. (1938), *Chin. Journ. Physiol.*, **13**, 209.

0·62–0·75, and sorrel, which belongs to the related buckwheat family, 0·27 per cent. Other figures [1] are: cabbage, 0·005–0·009; leeks, 0·017; lettuce, 0·002; rutabaga, 0·014; strawberries, and tomato, 0·026 per cent.[2]

The amounts of benzoic acid, both free and combined as a glucoside, in the cranberry and presumably in the whortleberry vary from 0·021 to 0·061 per cent. This will be excreted as hippuric acid in the urine and may outweigh the alkalinity of the ash of those fruits.

SUMMARIZING this chapter we may say:

1. The mineral elements which concern us most are calcium, iodine, iron, and phosphorus.
2. There is evidence of widespread lack of the three first in the diet of Great Britain if the usual estimates of the daily needs are accepted. Elsewhere, e.g. in India and China, the lack is still greater.
3. There is no reason, even in cases of poverty, why these needs should not be met.
4. A balance of acid-producing and alkali-producing foods is essential only when the kidney has difficulty in secreting acid or alkali.

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[1] YEH and ADOLPH. (1938), *Chin. Journ. Physiol.* **13**, 209.

[2] To prevent the oxaluria caused by eating spinach and rhubarb all that is necessary is to take some milk or cheese at the same meal. BARTLETT. (1944), *Lancet*, **2**, 574.

CHAPTER V

THE FUNCTIONS OF FOOD *(continued)*

(IV) THE SUPPLY OF VITAMINS

In 1912 a revolution in our ideas concerning the indispensable proximal constituents of a diet occurred.[1] Up till then it had been assumed that if the diet were adequate as regards Calories, protein (with fats and carbohydrates) and mineral elements, it would suffice for optimal nutrition. Since then we have added, one by one, indispensable organic catalysts which must be taken in the food either preformed or in a form which can readily be transformed into the specific catalyst. These catalysts we call the *vitamins*. Intense research upon this subject has given us in the last three decades very clear knowledge concerning the chemical nature of these catalysts and to some extent of the way in which they work. Although finality has not been reached, we none the less feel that it is improbable that any similar new surprise will be sprung upon us, and that the main lines have been sketched out so that it remains to fill in the details only. At any rate, looking on the matter from the point of view of practical dietetics we have such a body of knowledge that we can immensely improve the feeding of the individual and the nation by the supply of foods containing the known vitamins.

We have spoken of a revolution in our ideas in that sundry organic catalysts, in addition to the normal gross substances—proteins, fats, carbohydrates, and mineral elements—are indispensable. All revolutions have their seeds in the past and although it was not until 1912 that this particular revolution shook the theory of dietetics to its foundations, the first rumours were by then 300 years old, long before the dawn of inorganic and organic chemistry. The revolution was the result of the convergence of three lines of research.

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[1] For much of the discussion we are indebted to Dr. LESLIE HARRIS. (1938), *Vitamins and Vitamin Deficiencies*, **1**, Churchill; Medical Research Council's Special Report. (1932), *Vitamins: a Survey of Present Knowledge*; MCCOLLUM, ORIENT-KEILES and DAY. (1939), *The Newer Knowledge of Nutrition*, 5th edn.; ROSENBERG. (1942), *Chemistry and Physiology of the Vitamins*. BICKNELL and PRESCOTT. (1942), *The Vitamins in Medicine*.

1. Empirical observations that a food, e.g. the lemon, is a specific against a particular disease.

2. The discovery that animals can suffer from such diseases and the foods which are specific in curing them in man are specific for those animals.

3. Experimental results of feeding animals with highly purified food-stuffs.

Empirical Observations.—*Scurvy* is a disease which has been known from the time of the Dark Ages. It appeared during various sieges in history from that of Acre to that of Kut-el-Amara in 1917. It accompanied the sailor on his long voyages before the steam era. It dogged the footsteps of the Arctic and Antarctic explorers and may even now be seen sporadically in poor people, usually bachelors or spinsters, or in aged people whose diet is at fault. As long ago as 1601 the East India Company discovered that the disease could be kept at bay or cured by the juice of lemons and oranges. This fact was rediscovered by John Woodall in 1639, by Kramer in 1739, and by Lind in 1753. During the potato famine 1845–7 scurvy broke out in Ireland, and in post-vitamin days the same has been observed. Stefánsson cured colleagues sick with scurvy by giving them a diet of (mainly) raw meat.

In all this there is more than a hint that scurvy is due to a "deficiency" in the diet and that freshness of the food is in some way or another a specific.

Beri-beri is a disease of the East which was known in China in 2600 B.C. Takaki, in 1882, decreased the high incidence of beri-beri in the Japanese navy to vanishing point by altering the diet. He added fish, meat, vegetables, barley, and condensed milk to a diet consisting predominantly of rice, and the disease disappeared. Eijkmann, 1890 and 1897, discovered that the disease occurred when the diet was mainly composed of polished rice and could be cured by feeding the rice polishings. Here again was a disease caused by a food deficiency. Takaki imagined that the deficiency was protein, though Eijkmann's much later observations did not support that interpretation.

Pellagra is a disease of maize-eating countries, e.g. Spain, Italy, Rumania, Egypt, and the Southern States of the United States. Although a commission appointed in the United States came to the conclusion that defective sanitation was the cause of pellagra, one member of that commission, Goldberger, was convinced that it was dietetic. In a pellagrinous area, those who ate more meat, eggs, or milk escaped while those living on a poorer diet were attacked. Again a deficiency of the diet was inculpated, though Goldberger thought for many years that the cause was a deficiency of first-class protein rather than of a specific catalyst or vitamin.

Rickets. For a hundred years or more the connection of rickets with a faulty diet was suspected and a specific—cod-liver oil—known. Schuette, writing in 1824, said that " its potency may be due to an imponderable amount of substances which produces marked changes in the body, but cannot be determined by the chemist." Cheadle in 1899 wrote that " Rickets is produced as certainly by a rachitic diet as scurvy by a scorbutic diet " ; and Hopkins in 1906, adumbrating the discovery of the vitamins : " In diseases such as rickets, and particularly in scurvy, we have had for long years knowledge of a dietetic factor. . . . They [the errors in diet] are, however, certainly of the kind which comprises these minimal qualitative factors that I am considering."

Thus there arose an idea that some diseases are connected with a deficiency of specific factors, not proteins, fats, carbohydrates, or inorganic elements, but accessory thereto. What the functions of these accessory factors were was not by any means clear. Did they counteract the effects of a constituent of the diet present in excess or were they important because of some positive, and not negative, contribution which they had to make ? At first Eijkmann considered that the factor in rice polishings had the function of combating the effects of an excess of carbohydrate in the diet, but later developments in his own and other researchers' work pointed conclusively to the view that these accessory factors were needed in diet, not for any neutralization of the effects of the main constituents, but because they catalysed some of the normal functions of the body.

Evidence from Diseases in Animals. Perhaps the most valuable discovery in dietetics is that animals may suffer from diseases which are analogous with those of the human being. Eijkmann in 1890 showed that chickens suffered from a disease which bore a close resemblance to human beri-beri, and that it could be produced in them as in man by a diet consisting of polished rice and cured in them by rice bran and (in later work) by watery and alcoholic extracts of rice bran. Holst and Frölich in Norway, trying to extend Eijkmann's work to guinea pigs, discovered that the unbalanced diets they gave resulted in a disease that closely resembled human scurvy. In post-" vitamin " days these observations have been extended to other animals and it has been found that the rat can suffer from beri-beri, or rather a paralysis which closely imitates the paralyses seen in human beri-beri, from an eye disease[1] the later stages of which are xerophthalmia and keratomalacia, and from rickets ; the dog from a disease—canine hysteria—which is connected with deficiency of the substance that cures or prevents beri-beri ; from black-tongue or the Stuttgart disease—which has something in common with pellagra, and from rickets ; the pig from pellagra, and the domestic fowl from rickets as well as beri-beri.

It is not too much to say that the discovery that animals suffer from the same deficiency diseases as man made the astounding rate of advance of our knowledge concerning the vitamins possible. Without them we should still be debating the cause of the so-called deficiency diseases.

Evidence from the Feeding of Synthetic Diets. Although the scientific and experimental foundation of the doctrine that there are such factors in diet, present in minute amounts and essential to life, must always be associated with the name of Hopkins, whose work on the subject was begun in 1906 and published in 1912, there had been indications of the possibility of these factors in the work of Lunin, 1888 ; Socin, 1891 ; Pekelharing, 1905 ; and Stepp, 1909, 1911, and 1913. All of these postulated something in natural food other than the known principal ingredients—proteins, fats, carbohydrates, and mineral elements—essential to life. The work of the three earlier investigators was overlooked either because the physiological world was not yet sensitive to the implications of the work or because it was, as in the case of Pekelharing, published in the Dutch language. Stepp's work on the lipoids came at a time when other workers were preparing the way and only helped to confirm the views so admirably stated and so well based on sound experimental work in the classical paper of Hopkins in 1912. He has well been proclaimed "Der geistige Vater der Vitaminlehre."

Hopkins fed young growing rats on a diet of highly purified protein (caseinogen), lard, starch, cane sugar, and inorganic salts. They failed to grow after a few days and then declined in weight till at the 18th or 20th day they weighed no more than at first. If, to the rats on this diet, there were given at a different time of day 3 c.c. of fresh milk or small amounts of an extract from mangolds, or of protein-free and salt-free extracts of milk solids or of yeasts, the animals grew at a rate comparable with the normal growth on a mixed diet. Moreover, the animals looked fit and were active, whereas those on the purified diet did not.

Many possible objections to the validity of the conclusions of

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[1] According to a communication to one of us (V. H. M.), Hopkins was aware of this, and of the cure by green food, well before 1912.

Lunin were ruled out by Hopkins' work. He showed that the lack of growth was not due to the monotony of the diet or to its lack of palatability or flavour. Nor was it due to lack of consumption or failure in absorption. The animals which showed the decline in weight and health were consuming more than a sufficient quantity of food to maintain health. In fact they often consumed more of the basal dietary than the animals which were growing satisfactorily on the basal diet plus the additions mentioned above.

The additions did not supply much energy. Even with milk the addition was only 4 per cent. of the total energy of the diet eaten, whereas with the extracts of milk or yeast the addition to the energy value of the diet must have been exceedingly small, for they worked in "astonishingly small amounts."

This work of Hopkins clinched the case for the "accessory factors" as he termed them: these are substances—not proteins, fats, carbohydrates, or mineral elements—essential to life. Funk christened these accessory factors "*vitamines.*" He put forward the theory that scurvy, beri-beri, pellagra, and possibly rickets are caused by the absence from the diet of "special substances which are of the nature of organic bases, which we will call the vitamines." The name caught the popular imagination and, though it has been shorn of its "e" because it wrongly suggests that all the vitamines are amines, it still holds the field. We do not propose to give any account of the floods of research in all countries on vitamins, but to jump to modern times and explain the state of affairs to-day.

There are at least six important vitamins intimately concerned with human nutrition and there may be many more. Each, as its chemistry is made clear, has been or will be given a name which will, it is hoped, take the place of the provisional letters assigned to them while they were observable only through their activity and not in the isolated form. By to-day we know the chemistry of most of them, and can synthesize them. The facts thus discovered make us wish that the name vitamin had not been invented. ("Accessory factors" would have been much better.) Chemically speaking, it is wrong because some of them contain no nitrogen. And practically it is unfortunate because the lay public, and others, assume that because they have the same name they all behave alike, e.g. that they are all heat-labile, or that they all occur in the same food.[1] Nothing is further from the truth. One food may be excellent for one vitamin and yet be totally devoid of another. One vitamin may be unstable to heat whereas another is so resistant that it may be distilled at a high temperature. It will take many years to eradicate from the minds of the public the false ideas sown by the use of the term vitamin.

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[1] For example: "You can kill them vitamins if you only boils 'em long enough." "Wholemeal bread only is used for the vitamins." "We give plenty of fruit and vegetables for the vitamins" for which see any popular article on diet and many school prospectuses.

Provisionally as their effects were discovered the vitamins were labelled A, B, C, etc., after the letters of the alphabet. Then B proved to be not a simple substance but a mixture of substances, and so we have been saddled with B_1 and B_2. B_2 also is a complex, but as B_3 and B_4, not to mention B_5 and B_6, had already been allocated there would have been trouble had not the chemistry of the component parts become clear. As it is, names for vitamins are in a transitional state. The old alphabetical nomenclature has not vanished nor is the new completed.

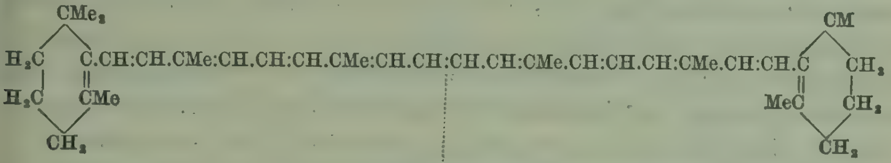
Another difficulty must be stated. The action of what we used to think of as one chemical substance may be performed by two or more substances having similar chemical structures or similar configurations in space. Keys to pick a lock need not be identical, but they must have some general likeness. Similarly two substances which may cure rickets, though they may not have identical structure, will have closely approximating structure. The most illuminating examples are the various substances produced by ultra-violet light on the sterols. One will cure rickets in rats but not in chicken, another in chicken but not in rats, whereas both are curative in man.

Finally, there are substances like choline, unsaturated fatty acids, and amino-acids, which enter into the structure of the tissues but none the less have activities like the vitamins. These substances Rosenberg prefers to call vitagens to distinguish them from the vitamins which he defines as "organic compounds which are required for the normal growth and maintenance of life of animals, including man, who, as a rule, are unable to synthesize these compounds by anabolic processes that are independent of environment other than air, and which compounds are effective in small amounts, do not furnish energy and are not utilized as building units for the structure of the organism, but are essential for the transformation of energy and for the regulation of the metabolism of structural units."

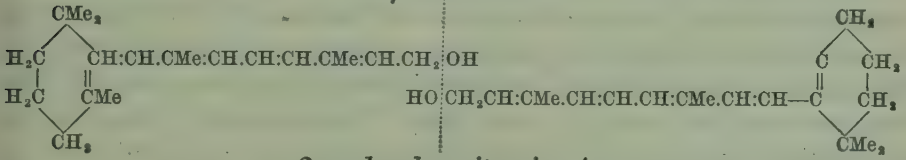
Vitamin A and the Active Carotenoids.

Vitamin A is a colourless alcohol which is taken either in the food as such (e.g. in liver or liver oils) or as a precursor, the well-known orange-coloured terpene carotene (e.g. in palm oil, carrots or green vegetables). The carotene, or allied substances such as cryptoxanthin (from cape gooseberries, yellow maize, paprika, etc.), echinone (from sea-urchins, used as a food around the Mediterranean are transformed into vitamin A in the liver. Other yellow pigments such as lutein (or xanthophyll, the yellow colouring matter of eggs) and zeaxanthine (one of the pigments of maize) cannot be so converted. All the carotenoids are not equally valuable. Thus β-carotene is the most active, having apparently half the activity of preformed vitamin A, while α and γ carotene have less.

We might expect β-carotene to produce two molecules of vitamin A. It is symmetrical and it conceivably could be split into two equal halves and the adjacent ends oxidized to an alcoholic group, thus:



β-carotene.



2 molecules vitamin A.

But feeding experiments seem to show that molecule for molecule carotene has only half the effect of preformed vitamin A. This discussion is not so academic as it may seem, because in the tables of vitamin values the figures are sometimes based on feeding experiments (biological assay) and sometimes on chemical estimates of the carotene content. In using these tables, if only carotene estimations are available, the figure given should be halved. We judge foods by their vitamin A effect, not by their content of carotene, and we compare them with each other through the international standard, which, however, is a highly purified sample of β-carotene. 0·6 microgrammes[1] of this standard is the *International Unit.* When 100 grammes of a given food is equivalent in its vitamin A activity to, say, 6 microgrammes of the international standard we say that 100 grammes of this food act as if it contains 6 ÷ 0·6 = 10 International Units of vitamin A.

Vitamin A is soluble in fats and fat solvents (whence its old name Fat-soluble A) and therefore in medicinal paraffin. It gives an intense blue colour in combination with antimony trichloride and also has a characteristic ultra-violet spectrum. Both vitamin A and carotene are insoluble in water and are therefore not washed out of food-stuffs by boiling or steaming. Though both are susceptible to oxidation at room temperatures there is little evidence that vitamin A is destroyed by cooking[1] even by such drastic processes as shallow frying, roasting, or pastry-making, where the medium in which the vitamin is carried comes into contact with very hot air. Canning does not destroy it, nor does it disappear from the milk in a milk pudding. Kon states that there is no loss when milk is dried.[2]

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[1] 1 microgramme or 1 $\gamma = 1$ thousandth of a milligramme, i.e. 1 millionth of a gramme.

The body has some difficulty in absorbing carotene, though not so much with vitamin A. This is especially marked when fat absorption in the small intestine is deficient as in jaundice, cœliac disease and steatorrhœa. Medicinal paraffin oil cuts down the absorption of carotene and to a less extent of vitamin A. Consequently it is best to take that medicament the last thing at night, as long as is possible after the meals containing vitamin A or its precursor.

The subtlest test for deficiency of vitamin A or its precursor is a measure of ability to see in light of low luminosity. In the retina, or rather just behind it, is a layer of cells which manufacture a pigment, rhodopsin, which sensitizes the rods of the retina. The rods are used for vision in dim light. The pigment is bleached in bright light and has to be regenerated when the eye is adapted to the dark. As this pigment is a compound of vitamin A and protein, the power to adapt to darkness, i.e. the power to regenerate this pigment, must depend on the presence of vitamin A in the blood. Consequently a measure of our power to see in the dark (which fortunately can be obtained with some approach to accuracy)[3] is a *measure of our saturation with vitamin A*. Many workers in the United States, Scotland, England, and Belgium are satisfied with the accuracy and constancy of this test, though others prefer scepticism.

At a greater stage of deficiency, night-blindness, or complete inability to see in the dark, occurs. This trouble was described in Eber's Papyrus (1500 B.C.) and in Jeremiah xiv. v. 5, 6[4] and is still present with us, and not only in Newfoundland, Labrador, China, Brazil, and the Dutch East Indies, but in England.[5] Later follows the appearance of Bitot's spots, then xerophthalmia and keratomalacia. The two last are due to microbic invasion of the conjunctiva of the eye and the cornea. If the keratomalacia is not arrested by a satisfactory diet the cornea perforates and total blindness ensues. In India to-day it is the chief cause of preventable blindness in children. As many as 2 per cent. of the children in Ceylon are blind as the result of obtaining too little vitamin A. That microbes can effect a lodgement in the eye is due possibly to two things, (i) a loss of the lysozyme, a substance in the tears which digests microbes, and (ii) degeneration of the epithelium covering the eye.

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[1] BOAS-FIXSEN. (1938-9), *Nut. Abs. and Rev.*, **8**, 281.

[2] KON. (1941), *Nature.*

[3] MAITRA and HARRIS. (1937), *Lancet*, **2**, 1009. See also HARRIS and ABBASY (1939), *Lancet*, **2**, 1299, 1355.

[4] . . . their eyes did fail because there was no grass.

[5] SPENCE. (1931), *Arch. Dis. Child.*, **6**, 19.

Structures of epithelial nature all over the body degenerate as the result of deprivation of the body of vitamin A. Thus the linings of the respiratory tract and the urogenital tracts "keratinize" and are more susceptible to bacterial invasion. The skin itself alters its nature. Babies are more likely to suffer from mild skin eruptions (Helen Mackay). In Ceylon [1] and Kashmir [2] an inflamed and coarsened condition of the skin (toad-skin, phrynoderma) is accounted for by a deficiency of vitamin A in the diet.

Finally, there is incoordination of the growth of the bones of the skull and the spinal column, so that they encroach on the nervous system and damage the sensory tracts. Vitamin A, by regulating the activities of bone cells, coordinates the adjustment of bone and nervous system growth.[3]

As a result of this degeneration in epithelial structures and in *afferent* neurones it is not astonishing that this vitamin was at one time termed the anti-infective vitamin. Afferent nerves have a trophic effect on the epithelia. Degenerate epithelia can be attacked by microbes. Diseases of the epithelia and glands—abscesses, broncho-pneumonia, stone in the kidney and bladder, puerperal pyrexia—are more common in animals and human beings when the diet is deficient in vitamin A. But although this vitamin, by preserving the epithelia, protects from disease, once the disease has got a hold, exhibition of the vitamin does not necessarily shorten the attack. It will certainly clear up a xerophthalmia, but it has no effect on a widespread infection.

Like all the other vitamins, vitamin A and its provitamin, are rather erratically distributed among food-stuffs. The chief sources are fish liver oils, mammalian liver fats, fish body oils, dairy foods, and green and yellow vegetables. As figures are now available for the vitamin A, or provitamin A content of foods, it is reasonable to let the figures speak for themselves with one proviso : that they be taken more as " illustrations than arguments." Foods vary so much from time to time and place to place and from investigator to investigator that we cannot take the tabulated results in more than an impressionistic way. Most of the figures will be taken from Roscoe and Fixsen,[1] but other estimates are included.

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[1] NICHOLLS. Quoted by HARRIS. (1935), *Vitamins*. O.U.P.

[2] WILSON. (1939), *Lancet*, **1**, 1019.

[3] MELLANBY, E. (1944), *Proc. Roy. Soc. B.*, **132**, 28. WARKONY, NELSON and SCHRAFFENBERGER, (1943), *Am. Journ. Dis. Child.*, **65**, 882; quoted in *Lancet*, (1944), **1**, 316, suggest that hare lip and cleft palate may be due to vitamin A deficiency.

Vitamin A contents of Foods, I.U. per 100 grammes (or about 3½ oz.)

Cereals.	Yellow maize	300–900	Carotene estimations	
	Whole wheat	100–460		
	Wheat germ	650 (biological assay)		
Dairy Products.				
	Butter	1130–3590	Biological assay	
	Cheese	1100–4000	,, ,,	American figures
	Cheddar, from winter milk	550	,, ,,	English ,,
	,, ,, summer ,,	1440	,, ,,	,, ,, .
Eggs.	Yolk	8000	,, ,,	or 1200 per egg
	Whole egg	700	Spectrophotometric assay	,, 350 ,, ,,
	,, ,,	1000[2]	?	,, 500 ,, ,,
Milk.	Jersey, winter	30	Biological assay	170 per pint
	,, summer.	690	,, ,,	3910 ,, ,,
	Mixed, pasteurized :			
	winter	60	,, ,,	340 ,, ,,
	summer.	540	,, ,,	3060 ,, ,,
Fish and Fish Liver Oils.				
	Herring, fresh	141	Mean of several methods.	40 per oz.
	,, canned	28		8 ,, ,,[3]
	Cod-liver oil	10,000–400,000	Biological assay	3500–14,000 per teaspoonful
	Halibut liver oil	3,000,000–36,000,000	,, ,,	1200–14,000 per drop
Fruits.	Apricots, fresh	1800–2300	Carotene estimations	
	,, dried	5000–5500	,, ,,	
	Nectarines	720	,, ,,	
	Orange juice	300–400	,, ,,	
	Peach (yellow)	760	,, ,,	
	Tangerine orange	690	,, ,,	
Livers.	Cows, Winter	5300–45,000	Summer	3600–30,000
	Heifer ,,	1900–12,000	,,	7500–37,500
	Ox ,,	600–11,000	,,	1700–25,000
	Sheep ,,	30,000–60,000	,,	19,000–82,500

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[1] Roscoe and Fixsen. (1937–8), *Nut. Abs. and Rev.*, 7, 823, and (1939–40), 9, 795.

[2] *Nutritive Values of Wartime Foods.* 1945.

[3] Bacharach *et alii.* (1942), *Brit. Med. J.*, 36, 34.

VEGETABLES.

Beans, green, tinned and strained	—		950	Biological assay
Cabbage	—		900	,, ,,
Carrot	2000–13,200	Carotene estimations	1900–6500	,, ,,
Green peas, tinned	139–2000	,, ,,	700	,, ,,
Spinach:				
fresh	2630–48,000	,, ,,	13,000	,, ,,
tinned and strained			12,230	,, ,,
Sprouts	210–650	,, ,,	—	
Tomatoes	14,000–36,000	,, ,,	3000	,, ,,
tinned and strained	—		4300	,, ,,

In these tables only outstanding figures among the various types of foods are given. It will be seen at a glance that the cereals are negligible sources, only yellow maize being of much value.[1] It is interesting to note that white maize with no carotene is preferred to yellow in making the hominy porridge (" grits " in the Southern States), and among poultrymen in this country, another illustration of the passion for whiteness in foods as against colour.

Fruits, again, are of little value, only yellow fruits having useful amounts.

The outstanding sources of vitamin A are the dairy foods, mammalian livers and fish liver oils, vegetables having, with the exception of carrots, spinach and tomatoes, only useful amounts.

The carrot, since it contains very considerable amounts of carotene, was perhaps too well advertised by the Ministry of Food in the second year of the second World War. But despite the fact that the body has difficulty in absorbing the carotene from the carrot, especially when eaten raw, it will always be a useful source of vitamin A activity. Tomatoes, which we have placed among the vegetables, following normal usage, though they are fruits, are more valuable for vitamin A activity than for vitamin C. This activity is due, not to the carotenoid pigment lycopene, but to β-carotene, the colour of which is masked by the intense red of the lycopene. Attention is called to the large amounts in spinach among the green vegetables.

A note is essential on the dairy products. These show extraordinary variability depending on the time of the year. This is due to the fodder of the animals. The figure is usually at its lowest ebb in February and March, and rises to its maximum in

[1] It is probable that the vitamin A content of whole wheat has been overestimated; see the M.R.C. War Memorandum 14. *Nutritive Values of Wartime Foods.* 1945.

May and June when the flush of new grass increases the carotene intake. There is a bigger seasonal variation of the carotene in the milk than in vitamin A.[1] Stall-fed cows are bound to give a milk with a lower vitamin A activity than ones fed on green grass, though if dried grass replaces hay feeding in the winter it may result in winter milks having a higher figure than hitherto. Naturally this fluctuation in the vitamin activity of milks is reflected in the butter and cheese made from them. Winter butters have much less activity than those of early summer. Butters from Australia and New Zealand have a higher average than those from England and Scotland, for green fodder is available for much longer periods.

Cheese being usually made from surplus summer milk has a good vitamin A activity. Most of the figures quoted by Fixsen and Roscoe are of American origin and run from 1100–4000 per 100 grammes (310–1130 per ounce) according to the make, Camembert, Danish Blue and Rocquefort being the highest. Figures from the National Institute for Dairy Research, still unpublished but which we have kind permission to quote, are as follows. Cheeses made from summer milk give figures of 1440, 1410 and 1850 per 100 grammes for Cheddar, Cheshire and Stilton respectively. For similar cheeses made from winter milk the figures are 550, 530 and 620. These work out at 418 I.U. per ounce for summer Cheddar, and at 156 I.U. per ounce for winter-milk Cheddar.

As the transformation from carotene to vitamin A almost certainly takes place in the liver in mammals [2] we should expect liver to contain large amounts and to show the same fluctuation with the seasons. This is so. The figures quoted in the tables are those of livers from the Cambridge Co-operative Society.[3] These figures, which are by no means so spectacular as those quoted from American sources, do, however, show the great value of liver in supplying vitamin A in the diet. An ounce of liver may easily supply 1000 I.U. and maybe 10,000. Sheep's liver, even in the winter, can supply 10,000 to 20,000 I.U. per ounce. Since vitamin A can be stored, a helping of liver might supply a whole week's ration of vitamin A.

Fish body-oils are sometimes claimed to have large amounts, but the work of Bacharach [4] and colleagues has shown that for the English herring this is not true. In case of need, fish liver oils are the standby for vitamin A therapy and will always remain the chief source of concentrated supply.

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[1] Heilbron and Gillam. (1937), *Nature*, **139**, 657.

[2] Moore. (1930), *Biochem. J.*, **24**, 692.

[3] Moore and Payne. (1942), *Biochem. J.*, **36**, 34.

[4] *Brit. Med. J.* (1942), **2**, 691.

Amount of Vitamin A Required. Though there is general agreement about the average amount of vitamin A needed per day it must be recognized that individual needs may show the widest variations. The Americans put the figure at 5000 I.U. for the adult man or woman; 6000 for the pregnant woman and the adolescent boy, 8000 for the nursing mother, 5000 for all girls over 13 years of age and for boys from 13–15. Children under 1 they estimate need 1500 I.U. and the figure rises by steps to 4500 for those between 10 and 12. These figures of the National Research Council appear high. Booher, in the United States, puts the figure at 3000 for the adult; Stickling at 4000; the League of Nations recommends 5000 for the pregnant and nursing woman. This diversity of figures suggests that we do not know the best figure, nor do we know how people vary in their requirements. It does not follow that what is enough for one person is enough for another. For example, not all people are alike in the ease with which they can be made night-blind by deprivation of vitamin A. They may vary in their powers of remanufacturing visual purple, or, what is much more common, they may vary in their powers of absorbing fats, and therefore, presumably, vitamin A and carotene, from the small intestine.

This problem of availability appears in the discussion of every "nutrient" the body takes. Are all the Calories from this or that food available? We know that they are not. If the food is indigestible a considerable fraction goes unabsorbed (e.g. high-melting-point fats); if there be much roughage present a smaller percentage of the food is absorbed than when there is little or none; if purgatives are taken more calorigenous material is unabsorbed; if there be diarrhœa or dysentery the same is true. Proteins, as they occur in the foods eaten, have different availabilities according to their digestibility and to the accompaniment with other substances, notably roughage. We have seen in the discussion on mineral elements that they too have different availabilities according to the form in which they are presented, the presence of phytates and oxalates, the motility of the gut and, probably, the secretory activity of the stomach. (A hypochlorhydria will probably make the calcium and iron less available.) So too, when we turn to the vitamins we shall find the same considerations applicable. Some alimentary tracts will be able to extract more of the vitamins from the food within them than others. To take an extreme example: some of the symptoms of sprue and the other dysenteries which beset the prisoners in Italian and Japanese prisoners of war camps may have been more due to vitamin deficiencies (particularly of the B complex), the result of defective absorption, than to the disease itself.[1] And it may easily be the case that absorption of vitamin A or its precursors may be upset by excessive mobility of the gut, by the use of purgatives and especially by the use of medicinal paraffin oil.[2] Consequently no hard-and-fast rule can be laid down concerning the vitamin A needs of any individual. Prisoners eating the same prison diet in Ceylon reacted to it differently. Some showed no signs of dietary deficiency, others showed avitaminosis A (phrynoderma 55 per cent., night blindness 30 per cent. and 1·7 per cent. keratomalacia) and still others showed avitaminosis B (neuritis, stomatitis and scrotal dermatitis).[3] Clearly no man's need is exactly the same as another's. Consequently, though we may accept the figures of 3000 to 5000 I.U. units a day as being a satisfactory intake of vitamin A, we must expect exceptions.

What classes of people attain this level ? According to Crawford and Broadley [4] none, even in the AA class, achieve the National Research Council's level ; the AA and the A class only—well-to-do people—achieve 4000 I.U. per day. In 1938 probably all classes with an estimated weekly income per head of 43 shillings attained 3000 I.U. per day. Investigations by the pupils of one of us (V. H. M.) into the dietaries of various schools of a charitable nature sometimes showed a marked deficit of vitamin A compared with even the low standard of 3000 I.U. per day. Against the American figure the deficit was always much greater, being 30 to 50 per cent. below. At one well-fed school, the quota of vitamin A was attained only because the children had cod-liver oil each day, otherwise there would have been a serious deficit.

And yet even the American estimated need is not too difficult of achievement. In summer it is easy—a diet containing milk, butter, cheese and green vegetables makes it certain. In February, March and April perhaps it is not so easy, and recourse should be had to reinforcing fish sauces with cod-liver oil where it is undetected, or to liver, liver pâtés or liver sausage. Probably it is wiser in winter to keep to the standardized margarines rather than butter which by the nature of its raw material cannot be, or has not been up to the present, standardized.

Vitamin B_1

After intensive work in Dutch, British, Japanese, and American laboratories, a crystalline substance was obtained from rice bran or yeast in quantities which could be submitted to chemical analysis.

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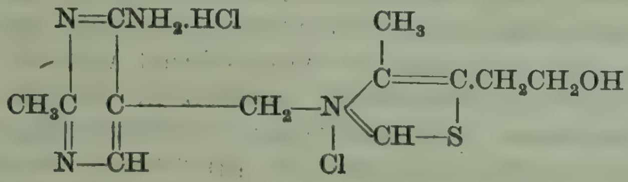
[1] Bloom. (1944), *Lancet*, 2, 558, 630. [2] *Lancet*, (1944), 2, 381.
[3] Nicholls. (1944), *ibid.*, 1, 630. [4] *The People's Food*, 157.

The result of the analysis pointed to the following structure, which was confirmed by synthesis : [1]



This substance consists of a pyrimidine ring (left) which is of frequent occurrence in substances interesting in biochemistry (e.g. nucleins, uric acid, caffeine) and (right) a thioazole ring which is unique in biochemistry, though not in commercial chemistry. As this vitamin contains sulphur Williams suggests the name thiamin for it. We should probably prefer to write it " thiamine." Donath had suggested " aneurin " in the days before its structure was known.

Vitamin B_1 is very soluble in water, and consequently some 50 per cent. goes into the surrounding fluid when fruits and vegetables are boiled. However, potatoes boiled in their skins lose only 10 per cent. of their vitamin B_1, whereas peeled and boiled they lose 25 per cent.[2]

This vitamin is somewhat sensitive to high temperature, though at the temperature of boiling water the loss by decomposition is negligible. At higher temperatures, however, the loss is much greater, consequently foods, more particularly meats and fish, which have been canned and " processed " at a high temperature, may have suffered very considerable loss. For example, Spruyt and Donath found that puffed rice, which is exposed to 15 atmospheres' pressure at 150° to 160° C., is devoid of vitamin B_1.[3] Losses up to 80 per cent. have been reported when meat is canned. Consequently, although we need not take into account the loss caused by the ordinary processes of cooking, we should not rely upon canned foods for our vitamin B_1. Condensed milk, however, is free from this stricture. There is no loss of B_1 during the baking of bread made with yeast, but baking-powder apparently destroys the B_1 in the flour and soda destroys it in soda cakes and scones. The vitamin is stable in the presence of acid but not in that of alkali.

Vitamin B_1 is, however, sensitive to sulphite even when the medium is acid, and destruction is quite rapid at p_H 6·6, the acidity of milk. Sulphite is permitted in sausages in this country to preserve them, though the fact must be declared. Pork contains a comparatively large amount of vitamin B_1, but as sulphiting results in appreciable loss of the vitamin we must not count on pork sausages as an important source of that vitamin.

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[1] Williams and Spies. (1938), *Vitamin B_1 and its use in Medicine.* The Macmillan Co. Williams. (1936), *Journ. Amer. Chem. Soc.*, 58, 1063. Williams and Cline. (1936), *ibid.*, 58, 1504.

[2] Baker and Wright. (1935), *Biochem. Journ.*, 29, 1802.

[3] Quoted by Boas-Fixsen. (1938–9), *Nut. Abs. and Rev.*, 8, 281.

When vitamin B_1 is markedly deficient in the diet, beri-beri occurs. This disease is of three types, (i) " Dry," when the main symptoms are neuritis and paralysis, (ii) " Wet," when they are mainly serous effusions and œdema, and (iii) " Fulminating " or " acute " with sudden onset of cardiovascular symptoms. Infantile beri-beri is nearly always of the last type.

As a diet, even in the Orient, is never totally deficient in vitamin B_1, the onset of the disease is insidious. It starts with fatigue, sensations of heaviness and stiffness of the legs, and inability to walk long distances. Then come headache, loss of appetite. dyspepsia, dizziness, and slow heartbeat. And last, sensory and motor paralyses (starting first in the lower extremities) and thence progressing up the body. The early symptoms are sometimes seen in this country in people on a diet for peptic ulcer, and indeed, progression to later stages.

In a study of symptoms seen in a group of volunteers at the Mayo clinic,[1] when they were restricted to a diet containing 0·4–0·45 milligramme thiamine (133 to 150 I.U.) per day, cardiac symptoms were a prominent feature. Pulse rate was slow when resting, abnormally fast on exertion. Cardiac sounds were faint and there was marked sinus arrhythmia. Anæmia, hyperchromic and macrocytic in type, was present. The basal metabolic rate was lowered 10 to 35 per cent. Intolerance to cold was observed. The subjects became depressed, irritable, quarrelsome and fearful, inefficient in work and unable to concentrate. They complained of soreness of muscles, fatigue, poor appetite, insomnia, headache, backache, gastric distress, paræsthesia, and intolerance to noise and pain. These symptoms disappeared when, unknown to the subjects, the intake of vitamin B_1 was increased.

In animals there is a widespread destruction of sensory and motor nerves, but this must be a terminal phenomenon. Paralyses in animals respond so rapidly to a dose of vitamin B_1 that repair of nerves would be impossible in the time. What is wrong in the earlier stages of beri-beri is an upset of carbohydrate metabolism in the central nervous system. Once the central nervous system is thrown out of gear it seems probable that all the other symptoms of avitaminosis B_1 occur as the result of its incapacity.

It has always been suspected that carbohydrate metabolism is somehow associated with vitamin B; and now we know that one moiety, B_1, is so bound up in nervous tissue and that together with others—riboflavine and nicotinic acid (or nicotinamide)—is bound up with the carbohydrate metabolism of the yeast cell.

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[1] WILLIAMS and MASON. (1941), *Proc. Mayo Clinic*, **16**, 433.

The brain tissue of a pigeon, which becomes polyneuritic as a result of lack of vitamin B_1 in its diet, fails to oxidize carbohydrate but is able to do so, even *in vitro*, when crystalline vitamin B_1 is added to the tissue.[1] So small an amount of vitamin B_1 as 1γ can cause 100 milligrammes of brain tissue to take up a very much greater amount of oxygen than could be used in oxidizing the B_1. Clearly the effect is catalytic and specific. No other known vitamin has the same effect, nor does absence of any other vitamin from the diet induce this inability to deal with carbohydrate. The metabolism of carbohydrates breaks down at the stage where pyruvic acid should be destroyed. It is significant that pyruvates appear in excess in the blood of rats and pigeons which have been deprived of vitamin B_1 in their diet and in beri-beri patients.[2] The failure to remove the pyruvic acid in nervous tissue—it is one of a cycle of reactions—brings nerve-cell metabolism to a standstill and so destroys its activity. Whether vitamin B_1 is essential to carbohydrate metabolism in other tissues of the body must remain an open question for the present. It is enough that it is essential for the normal activity of the central nervous system.

The International Unit. This originally was taken as the activity of 10 milligrammes of acid adsorbate from an extract of rice polishings. In future pure vitamin B_1 will be used as a standard. The relation between it and the old Unit is that 3γ of the pure substance has the activity of one International Unit. Further research may result in a readjustment of the standard unit, for the figure decided upon is the mean of a large number of observations, not entirely concordant, by different people.

Vitamin B_1 is *widely distributed among foods* but nearly always in very small amounts. All breads, except white baking-powder bread, contain it, though the more bran and germ they possess the more vitamin B_1 there is in the bread.[3]

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[1] PETERS. (1939), *Proc. Roy. Soc. Med.*, **32**, 807. It is not vitamin B_1 as such, but the pyrophosphate of the vitamin which has this action.

[2] PLATT and LU. (1939), *Biochem. Journ.*, **33**, 1525.

[3] According to HINTON. (1944), *Biochem. Journ.*, **38**, 214, 59 per cent. of vitamin B_1 is in the scutellum of the wheat. WARD. (1943), *Chem. and Ind.*, 11, estimates the content of the scutellum and the epithelial cells on the endosperm side of the scutellum at the high level of 49 and 42 I.U. per gramme.

		Units per gramme.	Units per lb.
CEREAL PRODUCTS.			
BREAD.	National Wheatmeal, 85 per cent. extraction	0·6–0·7	272–317
	"Plain" Scottish white	0·24	109
	,, ,, ,, 75 per cent. extraction.	0·24	109
	,, 70 per cent. extraction	0·25	113
	,, 60 per cent. extraction	0·16	73
	White	0·12–0·30	54–136
	White with malt	0·27 and 0·35	123–159
	Germ of wheat	0·80–1·70	364–772
	National Flour	0·8 –0·85	364–387
	Oatmeal (breakfast)	1·4	635
	Rye bread (rye ⅓, white flour ⅔)	0·45	220
	Wholemeal	0·75–1.30	341–590
FISH.	These have from 0·3 to 0·6 per gramme (the last figure being for herring roe), or 139 to 377 per lb.		
FRUITS.	Fresh	0·3 –0·5	136–227
	Dried	0·75–1·0	341–454
	Nuts	0·9 –2·0	408–907
MEATS.	These all contain about 0·5 per gramme or 227 units per lb. with the exception of those from the pig, which have much higher amounts, e.g.		
	Bacon, fried	2·8–4·8	
	Ham, boiled	2·2	1021
	Kidney, pig, raw	3·4	1568
	Pork, roast, lean	3·2	1486
			per pint.
MILK.	Raw and pasteurized	0·23	130
	Sweetened Condensed	0·4–0·6	
PROPRIETARY ARTICLES.			per lb.
	Bemax. Wheatgerm	15·0	6820
	Marmite	30	13,610
VEGETABLES.	These also contain from 0·3 to 0·6 per gramme, with the exception of the pulses (1·2–2·1), even canned peas having 1·2 per gramme or 556 per lb.		

The ***amount needed per day*** is a matter of some discussion, and there is an unacknowledged tendency among those who believe in the virtues of roughage and of wholemeal bread to raise the estimate and among those who depreciate these virtues to keep it low. Much too much emotion has crept into a discussion which should be coldly scientific.

A hard-and-fast estimate cannot be given because: (1) There is the probability of variability. Persons on exactly the same diet and in the same circumstances may need different amounts. (2) Absorption in different persons may be different. (3) There is an undoubted relation between Calorie output and the need for vitamin B_1, and the amount needed may vary more with the amount of calories obtained from carbohydrate than from the rest of the food. Increase of Calories in the food or of poisonous substances without concomitant increase of vitamin B_1 may precipitate an attack of neuritis. (Alcoholic neuritis and possibly the neuritis of pregnancy are connected with this.) (4) Fat, and more particularly the fatty acids with 6, 8, or 10 carbon atoms, reduce the need for vitamin B_1—another testimony to the value of milk and butter in the diet. (5) The microbic flora of the gut and the thiamine they hand over to their host may vary from time to time and person to person.

The best thing we can do at the present time is to give estimates by various people and leave the matter with the warnings, (i) that the figures are provisional guesses, and (ii) that if the reader feels he is "taking sides" he should beware of prejudice.

Cowgill . .	10 I.U. per 100 Calories, i.e. 300 I.U. for a 3000 Calorie diet.[1]
Van Veen .	150 I.U. the minimal protective dose for Orientals.[2]
„ „ .	200 I.U. „ „ safe „ „ „ [2]
Drummond *et alii*	200–500 I.U. the minimal safe dose for Europeans.[2]
Williams and Spies .	333–667 I.U. „ „ „ „ „ „ [3]
Harris . .	300–600 I.U. „ „ „ „ „ „ [4]
Plimmer and Plimmer .	450–750 I.U. „ „ „ „ „ „ [5]
Bigwood .	300 I.U. „ „ „ „ „ „ [6]
Williams and Mason . .	166–333 I.U. per 1000 Calories of the diet. [7]

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[1] Quoted by CALLOW. (1938), *Food and Health.* O.U.P.

[2] Quoted by WILLIAMS and SPIES. (1938), *Vitamin B_1.* The Macmillan Co. DRUMMOND, BAKER, WRIGHT, MARRIAN, and SINGER. (1938), *Journ. Hygiene,* **38**, 356.

[3] *Vitamin B_1.* (1938), The Macmillan Co.

[4] *Vitamins and Vitamin Deficiencies.* (1938), Vol. I. C.U.P.

[5] PLIMMER and PLIMMER. (1938), *Food, Health and Vitamins.* Longmans, Green & Co. 8th edn.

[6] BIGWOOD. (1939), *Guiding Principles for Studies on the Nutrition of Populations.* League of Nations Health Organization, Geneva. Published in Great Britain by Allen & Unwin.

[7] WILLIAMS and MASON. (1941), *Proc. Mayo Clinic,* **16**, 433.

All these figures are given by people who have been in close touch with work on vitamin B_1 or have actually been responsible for research work on it. The National Research Council of the U.S.A. has gone into greater detail and estimate as follows:

			I.U.
Man,	70 kg.,	sedentary	500
		moderately active	600
		very active	767
Woman,	56 kg.,	sedentary	400
		moderately active	500
		very active	600
		pregnant	600
		nursing	767
Child.	Under 1 year		133
	1–3 years		200
	4–6 ,,		267
	7–9 ,,		333
	10–12 ,,		400
Girls	13–15 ,,		467
	16–20 ,,		400
Boys	13–15 ,,		533
	16–20 ,,		667

We are aware that there is a big margin between the amount which will prevent beri-beri and the amount which is optimal. This margin exists because we have no accurate way yet of gauging the optimal figure. Are the lack of appetite, lassitude, dyspepsia, constipation and the many other symptoms of the patent medicine advertisements, an indication that we are not obtaining sufficient vitamin B_1? Who can tell? It may be so. On the other hand the apparent disappearance of these symptoms on increasing the intake of vitamin B_1 may have the same origin as the disappearance of symptoms after taking a patent medicine.

It will be shown later that a diet which is planned on the usual British convention and at the same time is satisfactory as regards calcium, iron and phosphorus, and vitamins A, C, and D will contain about 600 I.U. vitamin B_1 and is therefore presumably safe. For the rest we should advise increasing the intake in pregnancy and lactation by the use of marmite, Bemax and other B_1 preparations (see pp. 696–7) and, after investigating the diet, trying the effect of similar additions in any neuritis[1] or even in the vague malaises, fatigues and dyspepsias which are so common. The disappearance of symptoms after taking vitamin B_1 must, however, be critically and scientifically examined. Investigations by pupils of one of us

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[1] Theobald. (1936), *Lancet*, **1**, 834. Yudkin. (1938), *Lancet*, **2**, 1347. Price. (1938), *Lancet*, **1**, 831.

(V. H. M.) of the diet of schools of the public assistance type show that the probable intake was in all cases well above the American figure—i.e. highly satisfactory. This is a tribute to national wheatmeal bread of 85 per cent. extraction. It is indeed very difficult in this country to go without the quota of thiamine when eating national wheatmeal bread. One of the problems of the future is to get vitamin B_1 into the loaf and yet preserve that " whiteness " which is the desire of the millers, bakers and populace.

Vitamins of the B_2 complex

Undoubtedly the vitamin effect first studied as the result of Eijkmann and Grijn's work was that of thiamine and it was assumed that there was one single vitamin : water-soluble B in the bran, yeast, liver and other foods investigated for this action. But as work progressed it became clear that there was not one vitamin only, but many. With the progress of research the vitamins in these food stuffs have extended their ranks like the oysters in a famous poem. Often the clues to their existence were given by microbiology. Yeasts were stimulated to grow by such and such an extract but not by others. Microbes, such as lactobacillus casei, are very exacting and specific in their demands for vitamins. Some can synthesize one and not others. And by collating this work with experiments on vertebrates a long list of vitamins essential for vertebrates has been established. They are usually spoken of as the B_2 complex—an indifferent term. How far they all are important in human dietetics, as opposed to dietetics for microbes, is at present uncertain, for, though perhaps essential for human metabolism they may be of little importance in dietetics because (i) they are so widespread among foods and so little is needed per day that no one should ever lack them from the diet, and (ii) the microbes of the alimentary tract synthesize the wanted factors and hand them over to their host. This may at times happen even with thiamine.[1] They may have importance in medicine, as apart from dietetics, because sulphonamides given by mouth check the activity of the microbes inhabiting the gut, and may perhaps induce vitamin deficiencies.

Of the different moieties of the " vitamin B_2 complex " we name riboflavine, nicotinic acid (or nicotinamide), pyridoxine, biotin, paraminobenzoic acid, pantothenic acid, inositol and folic acid. There are others. We are certain that riboflavine and nicotinic acid (or nicotinamide) among these are important in human dietetics. We know now that biotin is essential for human metabolism but unless huge amounts of raw eggs are eaten it is unlikely that any deficiency of biotin in the dietary will be experienced. It is possible that the other substances mentioned may be important too, but more in medicine than dietetics, for sulphonamide therapy will stop the activity of the symbiotic microbes of the gut and cut off the source of supply of these vitamins.

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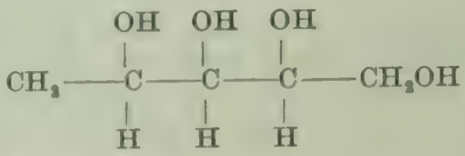
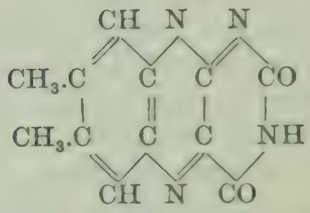
[1] Quoted by ROBINSON. (1944), *Chem. and Ind.*, 386.

Riboflavine

Riboflavine is a condensation product of ribose, which is a pentose sugar, and *iso*alloxazine as shown in



$$\mathrm{CH_2{-\!-}\overset{\overset{OH}{|}}{\underset{\underset{H}{|}}{C}}{-\!-}\overset{\overset{OH}{|}}{\underset{\underset{H}{|}}{C}}{-\!-}\overset{\overset{OH}{|}}{\underset{\underset{H}{|}}{C}}{-\!-}CH_2OH}$$



It was extracted from many foods, notably liver, milk, butter, and egg-yolk and was called hepatoflavine, lactoflavine, etc., according to its origin. When these substances were shown to be identical and the pentose sugar to be ribose, it received the name riboflavine. It is a greenish-yellow water-soluble pigment, and may appear free or in various combinations with phosphoric acid, adenine and protein in the body.

Warburg had already described a "yellow ferment" which catalysed oxidations and reductions in the cell, and this ferment is a compound of riboflavine, phosphoric acid, and a protein. Riboflavine is essential for the growth of experimental animals. For if these are fed on a diet of satisfactory Caloric value which contains only the vitamins A, B_1, and D, growth eventually ceases, but starts again when an adequate amount of riboflavine is given. It is not a big jump to suggest that riboflavine is a vitamin which is essential for the manufacture of Warburg's yellow enzyme, and that growth depends upon the presence of this enzyme.

Riboflavine can be detected either free in the animal body or as a compound with phosphoric acid, as a dinucleotide with adenine and as these two last in combination with a specific protein. The first three are readily absorbed by the alimentary tract but the combination with protein, found in vegetables, is not absorbed unless cooking has set the riboflavine free from the protein. It regulates not only carbohydrate metabolism but also fat and amino-acid metabolism.

Normally, human beings excrete some 500–800 microgrammes per day and the body has no storage capacity for this vitamin as is the case, too, with thiamine. As it is an important vitamin for rats, pigs, dogs, chicken and turkeys, it is not astonishing to find that it is important in man. Work by Sebrell and Sydenstricker in the United States has proved not only that it is important but that deficiency in the diet shows itself in a definite set of symptoms. These are angular stomatitis (cheilosis), a cracking of the skin with ulceration at the corners of the mouth, a seborrhœic inflammation in the labionasal fold, inflammation of the tongue which loses its papillæ and turns a magenta red in colour, becoming very sore, and an invasion of the cornea of the eye with blood capillaries. The last is perhaps the best diagnostic sign and the tentative explanation given is that riboflavine assists in oxidations in parts of the body where there is no blood supply and that the invasion of the cornea is an effort on the part of the body to supply oxygen when, owing to deficiency of riboflavine, the oxygen tension in the cornea is low.

Other defects of vision tentatively associated with lack of riboflavine are lowered capacity of seeing in the dark (compare avitaminosis A) and amblyopia.[1] This amblyopia may be due to a central or a ring scotoma.[2] Riboflavine is useful in treatment of these troubles, but nicotinamide in addition may be essential.

These last abnormalities of vision were shown in Japanese prisoners-of-war camps, and are due to diets defective in more than one essential. The problem for us is whether aflavinosis is at all common in " normal " times and surroundings. The answer is: yes. Hon[3] reports it as widespread in China. Nicholls[4] describes it in prisons in Ceylon and among children admitted to a children's hospital in Ceylon. In the United States, Sebrell and Sydenstricker have described cases among the poor and in this country physicians have seen angular stomatitis clear up on giving riboflavine. Sydenstricker, who has made widespread investigations in Great Britain during the Second World War, discovers that aflavinosis is very rare in this country. This absence has been somewhat carelessly attributed to our consumption of beer, which cannot be the case, for teetotallers suffer no more than beer drinkers; and it cannot be due to tea drinking because the 2 oz. ration of tea per week can by no means cover the supposed needs of the body.[1]

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[1] Wilkinson and King. (1944), *Lancet*, 528. Some think this condition is pellagrous.

[2] Greaves. (1944), *Lancet*, **2**, 227.

[3] Hon. (1940), *Annual Report of the Henry Lister Inst. of Med. Res.*, 24.

[4] Nicholls. (1944), *Lancet*, **1**, 630.

Recommendations by the National Research Council of the U.S.A. are that adult males should have 2·2 to 3·3 milligrammes per day according to activity; women 1·8 to 2·7, and 2·5 and 3·0 in pregnancy and lactation respectively; girls 2·0 around puberty and thence on 1·8; boys 2·4 at puberty and 3·0 from 16–20; and children rising in equally graded steps from 0·6 to 1·8 milligrammes. These amounts are almost certainly in excess of what people actually obtain in Great Britain, and there is evidence that less will prevent the appearance of symptoms. Thus when the diet in a camp in North Africa contained on the average 1·6 milligramme of riboflavine per day no stomatitis was seen, whereas when the riboflavine content of that diet sank to about 1·0 milligramme it appeared in 16 per cent. of the subjects. The stomatitis could be cured by riboflavine but not by nicotinic acid.[2] Macrae and others[3] have shown that when the average intake in the R.A.F. messes is 1·9 milligramme no signs of a flavinosis occur. Consequently we may assume that the minimal dosage is between 1·0 and 1·6 milligramme per day and in view of the immunity of the British Isles to aflavinosis pay little attention to the riboflavine content of our diet. If the diet is sound as regards vitamins A and B_1, it is probably sound as regards riboflavine.[4]

In the subjoined table a few estimates of the riboflavine contents of foods are given to two significant figures. Later work may alter these figures as the methods of estimation improve. They are taken from many sources but the majority are from Fixsen and Roscoe.[5]

It is unfortunate, perhaps, that this table lends itself to propaganda for proprietary articles, which the firms concerned will not fail to exploit. Within a short time of the publication of the relevant figures, attention was called to the riboflavine content of a pint of beer in the House of Commons but no one thought to mention the all-round values of cheese and milk as compared with beer.

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[1] Two ounces of tea would yield 73 microgrammes per day.

[2] Jones, Green, Armstrong and Chadwick. (1944), *Lancet*, 1, 720.

[3] Macrae, Barton-Wright and Copping. (1944), *Biochem. Journ.*, 38, 132.

[4] Bigwood. (1939), League of Nations Health Organization Publication, 88. "No basic diet can be made up which is devoid of lactoflavin."

[5] Boas-Fixsen and Roscoe. (1937–8), *Nut. Abs. and Rev.*, 7, 823.

Riboflavine Content of Foods in order of Magnitude

mg. per 100 g.		mg. per 100 g.	
3·3	Marmite	0·20	Ham
2·5–3·6	Baker's yeast	0·20	Mutton chop
2·3	Pig's liver	0·19	Brisket of beef
1·8–3·0	Brewer's yeast	0·17	Cheese, whole milk
1·6	Ox liver	0·14	Turbot
1·6–2·3	Meat extract	0·13	Pickled beef
1·5	Meat juice, concentrated	0·10–0·42	Herring
1·3	Skimmed milk powder	0·10–0·20	Nuts
1·06	Bemax	0·10	Honey
0·88	Tea	0·07–0·32	Mutton
0·53	Herring roe, soft	0·07–0·19	Corned beef
0·46	Lean beef	0·06	Spinach
0·41–0·62	Sardines	0·05–0·31	Cod
0·39–0·41	Cheese, skimmed milk	0·05–0·17	Beer, English war-time
0·30–0·40	Whole milk powder	0·03–0·07	Bread
0·30	Kipper	0·027–0·17	Milk

Nicotinic Acid

Quite the most startling advance in our understanding of the working of the vitamin B complex is the discovery of the importance of nicotinic acid or nicotinamide in diet. As already stated, Funk in 1912 put forward the idea that pellagra was due to the absence of a vitamin from the diet. This disease is characterized in its earlier stages by an inflammation and pigmentation of the skin on forehead, cheeks, hands and feet, and in its later stages by diarrhœa and dementia. It is particularly prevalent wherever maize is a staple food and apparently people on the verge of the disease may be pushed over the edge by infection with parasites or a lack of iron.[1] Such parasitic infection is common among the fellahin in Egypt who suffer from pellagra, though it is not the exciting cause.

Dogs suffer from a disease, " blacktongue," which for long has been considered to be the same disease, and pigs on a diet consisting largely of maize become very ill with pigmentation of skin and weakness of legs.

Now the heat-stable constituent of yeast, which was originally called B_2, cures pellagra and blacktongue, while riboflavine does not. Therefore it was suggested that a moiety of B_2, which cures dermatitis in rats, B_6, might be essential for man and would cure pellagra. This is not true. The truth was discovered in an odd way.

Funk, in his search for " vitamine " in rice bran, isolated nicotinic acid, but as this did not cure beri-beri its possible use in diet was overlooked for twenty years. Then Warburg found it, or rather the amide, in one of the co-enzymes (codehydrogenase II) which the yeast plant uses in making alcohol. Euler and his associates found that it was combined with adenine, ribose, and phosphoric acid to form the co-enzyme. It seems a big leap from yeast to man, but as there are distinct analogies between carbohydrate metabolism in man and the yeast plant, people tried the effect of nicotinic acid on pellagra. It cured blacktongue in dogs,[1] the disease of maize-fed pigs [2] and the skin lesions of man in England, Egypt,[3] and the United States of America. Ten milligrammes per day is a sufficient dose though it is usual to employ as much as 500 milligrammes to obtain a quicker response. These experiments suggest that nicotinic acid and its amide must be the main [4] missing factor in the diet responsible for producing pellagra.

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[1] Biggam and Ghalioungui. (1933), *Lancet*, **2**, 1198.

The classical picture of pellagra in man is of dermatitis, diarrhœa and dementia, usually seen in that order in the United States where the disease has been most investigated. But Sydenstricker is of the opinion that the order may be reversed and dementia appear first. It is notorious that in this country, where classical pellagra is very rare, that it is most frequently observed in our mental hospitals.[5] This is due to the difficulty of feeding patients with dementia of any kind. Moreover there are two other symptoms which frequently accompany pellagra : stomatitis and glossitis, and the inflamed mouth is often infected with the micro-organism of Vincent's angina. Further, infection of the body by bilharzia, or the presence of anæmia, either nutritional or as a sequel to the hookworm infection, may precipitate pellagra. Pellagrous symptoms may accompany sprue, and there may be amblyopia due to lack of nicotinamide. In fact there is a tangle of symptoms sometimes considered pellagrous, sometimes due to aflavinosis or it may even be to lack of vitamin B_1. For example, the dimness of vision seen in patients may be due to retrobulbar neuritis (athiaminosis), vascularization of the cornea and scotomata (aflavinosis) or the amblyopia may be pellagrous (aniacinosis). We have seen that stomatitis and glossitis can be due to aflavinosis as well as to aniacinosis. All this leads to two conclusions, one hypothetical and one practical. Rarely is an avitaminosis pure. A person in a state of malnutrition probably has multiple deficiencies, of iron, of calcium, of vitamins A, D or K, of C or of any or all of the B complex. Which set of symptoms appears depends on chance or constitutional make-up. It may be neuritis or pellagra or scurvy, etc. Consequently it is best, first to make the diet as good as it can be made, i.e. give a diet with the optimal amounts of Calories, protein, mineral elements and vitamins;[1] and second, to treat any symptoms of deficiency (e.g. nutritional anæmia, neuritis, dermatitis, scurvy, etc.) with massive doses of the appropriate medicament: iron, thiamine, riboflavine, nicotinic acid, ascorbic acid, etc.

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[1] Elvehjem, Madden, Strong, and Wooley. (1937), *Journ. Amer. Chem. Soc.*, **59**, 1767.

[2] Chick, Macrae, Martin, and Martin. (1937), *Biochem. Journ.*, **32**, 10.

[3] Harris and Hassan. (1938), *Lancet*, **234**, 944.

[4] Stannus. (1940), *Lancet*, **1**, 352, considers it to be due to a faulty production of a coenzyme.

[5] Watson. (1924), *Ann. Rep. Lunacy Comm.*

As was said above, pellagra is rare in Great Britain,[2] but it does not follow that subclinical cases are not present among us. For example, one of us (V. H. M.) has seen a long-standing soreness of the tongue and bilateral redness of the skin of the cheeks clear up as the sequel to taking 1 oz. of baker's yeast per day. The questions are, how much nicotinic acid do we need per day and how much does the diet contain?

Ten milligrammes per day will usually prevent pellagra though larger doses, up to 500 milligrammes per day, are necessary for a rapid cure, and 10 milligrammes has been adopted by Bacharach and Drummond. The National Research Council of the U.S.A. put the figure considerably higher: 15–23 for men according to activity, 12–23 for women according to activity and state, 4 to 12 for children according to age, 14 at puberty for girls and thence on 12, 16 at puberty for boys and then 20 till adult stature is reached. Kodiček[3] is apparently satisfied that 12 milligrammes per day is enough.

A table, mainly following Bacharach's compilation,[4] is given on p. 160 of the distribution of nicotinic acid among foods.

We note in this table that among the normal food-stuffs meat, meat offal and fish stand high on the list; that yeast, as might be expected, contains large amounts and that the proprietary foods made from meat and yeast have the largest amounts. The potato among the vegetables shows up well; nor is white flour so far behind oats. The figures for maize are astonishing in view of the fact that the eating of a diet rich in maize and short of other foods leads to pellagra. The position of dried skimmed milk is interesting

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[1] Wilkinson. (1944), *Lancet*, **2**, 655.

[2] *Lancet*, (1940), **2**, 594.

[3] Kodiček. (1942), *Lancet*, **1**, 389.

[4] Bacharach. (1940–41), *Nut. Abst. and Rev.*, **10**, 459.

NICOTINIC ACID CONTENT OF FOODS, MILLIGRAMMES PER 100 GRAMMES.

CEREALS AND CEREAL PRODUCTS.		
	Bread, white	0·5
	,, Wholemeal	1·2
	Maize	0·9–1·6 (!)
	Oats, medium	1·0–1·1
	Rice, milled	1·6–2·4
	,, parboiled and milled	3·8
	Wheat, whole	4·7–5·3
	,, germ	2·7–9·1
	,, bran	5·0
	White flour	0·9–1·1
FISH.	Herring	2·9–4·0
	White, E.P.	1·7–8·4
FRUITS.	Apples	< 0·5
	Tomatoes	< 0·5
MEATS.	Offal. Heart	1·2–8·0
	Kidney	3·8–19·4
	Liver	9·3–46·0
	Tongue	12·8
	Muscle	3–18
MILK		< 0·1–0·5
	,, dried	2·5
	,, ,, skimmed	4·3–15·0
PROPRIETARY ARTICLES.		
	Beer	7·0
	Bemax	6·0
	Marmite	65·5
	Meat extract	37·5–102·5
	,, juice	34·5–61·5
VEGETABLES AND NUTS.		
	Cabbage	0·3
	Carrot	< 0·5
	Peanut	13·0
	Potato	1·0–2·0
	Soya bean	4·85
	Spinach	1·7
YEAST	(baker's moist)	7·4–12·0
	(brewer's ,,)	9·1–10·2
	Extract	47·7–49·7

in view of the fact that so much skimmed milk has been wasted in Great Britain in the past.

It is clear from this table that no one in peace-time need go without their ration of nicotinic acid and that even when severely rationed it is possible to attain it. The fact that so few cases have been reported during the war of 1939–45 in this country confirms this.

The general impression obtained from considering all the three moieties of the vitamin B complex is there is little reason to suspect a deficiency of any one of them in the diet in Great Britain, certainly so long as National wheatmeal bread is the bread eaten.

Other Moieties of the B complex

We have mentioned biotin, inositol, pyridoxine, paraminobenzoic acid, pantothenic acid and folic acid among the vitamins which may be essential to man. They are essential for microbes, chicken, mice and rats and therefore probably for man.

Biotin has been shown to be essential to man by a somewhat drastic experiment. Four volunteers were given sufficient raw egg-white to supply 30 per cent. of the Calories of their diet. This represented the whites of 80 eggs per day. Since the avidin of raw egg-white combines with biotin and renders it unavailable, this depleted the intake of biotin by the volunteers. After 3–4 weeks the subjects showed, among other symptoms, an ashen pallor of skin and mucous membranes followed by a browny desquamation. There were also muscular pains, lassitude and anorexia. The condition cleared up when biotin was injected—150μg being sufficient to maintain relief from the symptoms.[1] Biotin has been used successfully in combating baldness due to seborrhœa, but so far no cases of acute spontaneous deficiency of biotin have been described.

Biotin is widely spread amongst all vegetables, grains and nuts and in foods of animal origin—liver, kidney and eggs having the greatest amount and milk somewhat less. It is highly improbable that biotin deficiency will ever be observed in this country unless a freak dietary with multitudes of raw eggs be taken.

Much the same can be said of the other substances named. **Inositol** is found in fruits (especially oranges and lemons), in green leaves, in cereals (as the hexaphosphate), in skeletal and heart muscle, kidney, liver, milk and eggs. Bread (wheaten and rye) is bound to contain free inositol and porridge and oatcakes may contain a little.[2] No diet is likely to be deficient in inositol.

Pyridoxine occurs in seeds and cereals, especially in the bran and the germ. Liver and fish contain moderate amounts and milk, egg-yolks, lettuce and spinach small amounts. Rats fed on a highly purified diet containing no pyridoxine, get a dermatitis of paws, snout, ears, tail. Dogs, rats and pigs have epileptiform convulsions and develop a microcytic anæmia. Apparently there is no evidence that man suffers from a pyridoxine deficiency anæmia unless, as Györgyi suggests, chilblains may be related to it. It is much too soon to do more than speculate. A good diet chosen to contain first-class proteins, calcium, iron and vitamins A, C and D will cover the need for pyridoxine.

The same is almost certainly true for **p-aminobenzoic acid** and **pantothenic acids.** Absence of the former in the rat's diet causes greying of the black fur and it has been used in man to cure greying of the hair due to nutritional causes. It is extremely wide-spread in foods and moreover is made by the microbes inhabiting the gut, whence it can be absorbed. No one is likely—no one, that is, who is not undergoing treatment by sulphonamides—to be without a sufficiency of *p*-aminobenzoic acid, obtained either from food or the microbes of the gut.

Pantothenic acid—its name means that it is found everywhere—

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[1] Sydenstricker and others. (1942), *J. Amer. Med. Ass.*, **118,** 1199.

[2] McCance and Widdowson. (1944), *Nature,* **153,** 650.

is widely dispersed in food, liver and kidney being the best sources, the rest of the offals coming next, and finally meat. Green plants manufacture it and store it in their seed coats. Black treacle is a good source.

Folic Acid, which is found in leaves, liver, kidney and yeast has become very important clinically. It is a condensation product of a pteridine molecule with paraminobenzoic and glutamic acids. It cures the anæmia of pernicious anæmia and other hæmolytic hyperchromic anæmias. Although so potent in this, it does not prevent the neurological complications which may occur coincidently with, or independently of, the hæmolytic anæmia. It also cures tropical sprue and some kinds of non-tropical sprue but not, it is said, coeliac disease in children.[1-6]

Of the remaining portions of the B complex,[7] it may safely be said that our needs for them will be covered by a diet satisfactory for the main mineral elements and vitamins.

Summarizing, the chemistry of vitamin B is mainly that of yeast, bran, germ, liver and leaves and the ferments and coferments of the cell in carbohydrate metabolism. Three of these vitamins, thiamine, riboflavine and nicotinic acid, are notoriously deficient in the diet of the poor in Asia ; while nicotinic acid is deficient in the diet of Mediterranean countries and the Southern States of the U.S.A. Riboflavine deficiency is known in the U.S.A. but is rare in Great Britain. Though the appropriate vitamin may produce spectacular cures of the deficiency disease presenting itself, in the long run it is useless unless the all-round nutrition is improved.

Vitamin C or Ascorbic Acid

The history of the prevention and cure of scurvy presents many examples of the waywardness of human thought and action. It was known as early as 1601 that oranges and lemons kept scurvy at bay, but this was a secret and maintained so in the interests of commerce.[8] It was rediscovered by Lind in 1753. It was also

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[1] Lopez, Spies, Toca. (1946), *Journ. Amer. Med. Assoc.*, **132**, 906.

[2] Moore-Bierbaum ; Welch ; and Wright. (1946), *Jour. Lab. & Clin. Med.*, **30**, 10, 1056.

[3] Darby-Jones and Johnson. (1946), *Journ. Amer. Med. Assoc.*, **130**, 780.

[4] Harrison and White. (1946), *Lancet*, **2**, 787.

[5] Manson-Bahr and Clarke. (1946), *Lancet*, **2**, 903.

[6] Leading Article, *Lancet.* (1947), **1**, 182.

[7] Robinson. (1944), *Chem. and Ind.*, 370, 386 ; (1947), *Food Manufacture*, **22**, 71.

[8] Nixon. (1938), *Proc. Roy. Soc. Med.*, **71**, 193. See also Bourne. (1944), *ibid.*, **37**, 512.

known in the eighteenth century that sprouted seeds and grain were a preventive and cure (Bachstrom, 1734), and Captain Cook showed that living on the fresh fruits of the lands he visited reduced the cases of fatal scurvy among his sailors to zero. But all this was forgotten in the nineteenth century, despite the fact that the navy had abolished scurvy by introducing lemon juice into the diet. Its occurrence was due, it was said, to an altered acid-base equilibrium of the body, or, later, to the presence of microbes. It was not till Holst discovered that guinea-pigs, put on a diet of oats and autoclaved milk, suffered from a similar disease that an opportunity was given to find out what foods could prevent or cure scurvy. We now know that, alone of the animals, man, the primates and the guinea-pig, can suffer from scurvy, while the birds, cat, dog, rabbit and rat do not. To-day we are certain that all, or nearly all, of the symptoms of scurvy are due to the lack of a vitamin, which received the provisional name of vitamin C and now has been called by the first person to isolate it, ascorbic acid.

The first symptoms of onset of the disease, apart from the gloom, irritability, fatigue, giddiness on standing upright after having stooped, and condemnatory and uncalled-for argumentativeness described by Stefánsson—which indeed are common prodromata of most diseases—are soreness of the gums and pain in the joints. Later the gums are swollen and painful, the teeth become loose in their sockets, the pains in the joints on movement become unbearable, and the skin shows multiple petechiæ or bruise-like patches. Possibly the "growing pains" of the Victorian public schoolboy were a sign of incipient scurvy; possibly too the bouts of nose-bleeding.[1]

To-day the disease is rarely seen except on Arctic and Antarctic exploration (and now should never be seen again), during sieges (of which that at Kut-el-Amara, 1917, was the last) and in railway and other engineering construction camps. Sporadic cases appear among indigent bachelors and spinsters living by themselves and doing their own housework and catering, and it has been seen in young men living at home, having a midday meal in a city restaurant and returning in the evening to the "warmed-up" remains of a meal their parents had in the middle of the day. Elderly people, too, who on account of false teeth and flatulence and other alimentary troubles have given up fruit and vegetables may develop sore patches in their mouths and purpura which are readily cured by a daily dose of orange-juice.

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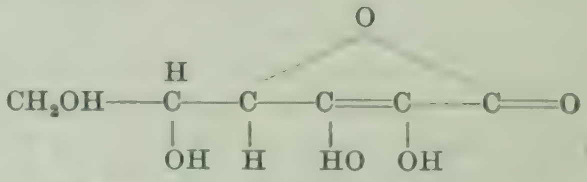
[1] FRIEND. (1935), *The Schoolboy.*

Practically all cases of gastric and duodenal ulcer [1] coming into hospital are woefully deficient in vitamin C, for it is fairly easy to detect a deficit (see later). This deficit is probably the result of omitting acid fruits, salads, and vegetables from the diet on account of dyspepsia, though we cannot entirely rule out the possibility that ulcers may result from a deficit of vitamin C in the diet.[2] There is a suspicious peak of incidence of peptic ulcers in late winter and early spring, and guinea-pigs on a prescorbutic diet frequently have them (20–30 per cent.). No wound heals well if an animal, and probably a human being, is kept on a diet with but small amounts of the vitamin in it.

The elucidation of the chemistry of vitamin C is interesting in view of the international collaboration involved. Holst and Frölich, Norwegians, started experimental work on animals. Zilva, at the Lister Institute, noted that fresh lemon-juice reduced a blue dye called indophenol blue. Tillmans and Hirsch in Germany used this fact to discover the age of lemonade " made from fresh lemon." Szent-Györgyi, a Hungarian, discovered a crystalline reducing substance in various plants and one or more animal tissues (notably the cortex of the suprarenal). The dye-reducing power of fruits or vegetables seemed to go parallel with their vitamin C activity. King in America obtained crystalline vitamin C from lemons and showed it to resemble Szent-Györgyi's reducing substance. Szent-Györgyi and Svirbely in Hungary tested the reducing substance on scorbutic guinea-pigs and cured them. Then Szent-Györgyi discovered a good source of it in paprika and sent a large sample to Haworth at the Birmingham University organic chemistry laboratory, where its structural formula was worked out and the compound synthesized. It is



$$\mathrm{CH_2OH{-}\underset{OH}{\overset{H}{C}}{-}\underbrace{\underset{H}{C}{-}\underset{HO}{C}{=}\underset{OH}{C}{-}C}_{\text{bridged by O}}{=}O}$$

In other words, it has the skeleton of a hexose sugar but it is "unsaturated." It can take up oxygen and also be reduced. Szent-Györgyi christened it ascorbic acid. In small doses, say 30 milligrammes a day, it prevents most of the symptoms of scurvy. But according to Szent-Györgyi the capillary fragility which gives rise to the petechiæ and the epistaxis of scurvy is due to a lack of another vitamin, vitamin P, which usually accompanies vitamin C.[1]

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[1] Harris, Abbasy, Roy and Marrack. (1935), *Lancet*, **2**, 1399; Archer and Graham. (1936), *ibid.*, **2**, 364; Bourne. (1938), *Brit. Med. Journ.*, **1**, 560.

[2] Smith and McConkey. (1933), *Arch. of Int. Med.*, **51**, 413.

Ascorbic acid is a white crystalline powder, very stable in the solid state, soluble in alcohol and in water, and unstable in solution in the presence of oxygen which it rapidly takes up. The oxidation is at one stage reversible but at more advanced stages it is irreversible and the vitamin is destroyed. Heat and alkali accelerate this destruction. Ascorbic acid acts as a reducing substance and this accounts for its power of decolorizing indophenol blue. In plant tissues there is an oxidase which, when the cell is damaged, destroys the ascorbic acid. This has bearing upon the marketing, the cooking and the preparation of fruits and vegetables for the table.

Marketing. Olliver [2] has shown that storage, even for a day or so, results in a loss of ascorbic acid from vegetables such as new potatoes, spinach, carrots and asparagus tips, but though this loss is serious, it has been exaggerated. Chappell,[3] investigating the amounts of ascorbic acid in the produce for sale in cheap and well-to-do markets in London, found that, though the street market fruits and vegetables on the whole had somewhat less ascorbic acid than those purchased in first-class stores, there was still enough left to supply a day's ration cheaply. None the less it is undoubted that the sooner a fruit or vegetable is eaten after it is gathered, the more ascorbic acid it will yield. Wilting and bruising and exposure of cut surfaces to air also decrease the ascorbic acid. First-class fruit and vegetables will probably be flown to markets after the war. Storage in a clamp, as potatoes are stored, lowers the ascorbic acid progressively. In September a main-crop potato may start with 30 milligrammes per 100 grammes to sink by the following March to the low figure of 7. Olliver gives figures about half of these.[4]

Preparation. It apparently makes a difference whether a vegetable is shredded with a sharp or a blunt knife. Swedes and cabbage, when grated, lose a considerable proportion of their ascorbic acid, even in five minutes; shredded with a suet grater there is a loss but it takes longer to show up; cut with a sharp steel knife there is little loss even after three hours.[5] Long chewing of salads is held by some to decrease the vitamin content appreciably, but others maintain that this is due to an oxidation to dehydroascorbic acid by the nitrite in saliva. It will probably be reduced again to ascorbic acid in the reducing surroundings of the stomach and intestine. Peeling and keeping potatoes overnight, contrary to widespread belief and statements by authorities, does not deplete the vitamin C.[1]

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[1] BENTSÁTH, RUSZNYÁK and SZENT-GYÖRGYI. (1936), *Nature*, **138**, 798.

[2] OLLIVER. (1936), *Chem. and Ind.*, **55**, 153.

[3] CHAPPELL. (1940), *Journ. Hygiene*, **40**, 701.

[4] OLLIVER. (1943), *Chem. and Ind.*, **62**, 146.

[5] PYKE. (1942), *Nature*, **149**, 499.

Cooking. It has been long known that ascorbic acid is labile to heat, wherefore it has been loosely and inaccurately stated that all cooking destroys the vitamin C value of cooked fruits and vegetables. This is far from the truth. There is a loss in cooking but this is partly due (i) to the action of the plant's oxidases, and (ii) to leaching of the vitamin into the cooking fluid. The oxidase works most rapidly between the temperature of 65° and 85° C. Above 85° C. it is destroyed. The problem then is to ensure that the vegetable is cooked in water which never falls below a temperature of 85° C. Obviously if it is put into cold water and brought to the boil, however quickly, the oxidase will bring about the maximum destruction. Even if it is plunged into boiling water in sufficient amounts to lower the temperature of that water below 85° C. destruction of the ascorbic acid will take place. In the R.A.F. the vegetables are added in three or four portions, one after the other, so that the temperature never falls far below boiling point.[2] Even so, if the proportion of water to vegetable is high, ascorbic acid is lost through solution in the water. This can be obviated by boiling the vegetables in relays, using the water from one lot to boil the second and so on, a method used in preserving the ascorbic acid in dehydrated vegetables.[3] The Ministry of Food recommends the following treatment to avoid losses of ascorbic acid in domestic cooking. A small amount of water is placed in the saucepan and brought to the boil. The vegetables, shredded with a sharp knife, are dropped in, the saucepan lid put tightly in position and the vegetables cooked partly in the water and partly in the steam above. Cooking is completed in about ten minutes. Constant attention is needed to prevent them from sticking to the pan and burning.

As a result of early work on the influence of alkali on ascorbic acid it has been too readily assumed that the addition of bicarbonate of soda to the water in which greens are boiled—a means of preserving the green colour—will destroy the vitamin C. Olliver[4] has shown that the addition of 2–4 grammes of sodium carbonate or bicarbonate to the gallon of water does not destroy vitamin C appreciably, though if the greens are kept hot after they are cooked it may accelerate destruction.

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[1] MARRACK *et al.* (1944), *Lancet*, **2**, 569.

[2] MACRAE. (1944), *Proc. Nut. Soc.*, **1**, 99.

[3] MAPSON. (1944), *ibid.*, **1**, 101 ; TRECHMAN. (1944), *ibid.*, **1**, 103.

[4] OLLIVER. (1943), *Chem. and Ind.*, **62**, 146.

The keeping hot of vegetables after they are cooked is very destructive of the ascorbic acid. Olliver[1] reckons the loss to be 25 per cent. after 15 minutes and 75 per cent. after 90 minutes. This is especially important where cooked vegetables are sent out from a central depot to canteens. Pupils of one of us (V. H. M.) found, for example, that whereas the vegetables as served at a canteen provided 7·2 milligrammes per helping, they would have provided three times as much if they had been served as soon as cooked.

Jams, if the fruits from which they are made contain vitamin C, retain a considerable amount. Thus blackcurrant jam (30 per cent fruit content) may have as much as 50 milligrammes ascorbic acid per 100 grammes, so that a helping may give 5 milligrammes—a useful amount.

Canning and Bottling. Owing to the prolonged high temperatures used in canning and bottling of fruits and vegetables it might be thought that there would be massive destruction of vitamin C. This is, however, far from the truth. As none but the best of fruit and vegetables fresh from market-gardens can be used for canning; as the produce is "blanched"—i.e. treated with boiling water for a short time before canning; as the head room of air in the cans is reduced to a minimum, the amount of vitamin C in the "pack" is often but very little less than that of the same garden produce cooked in the normal way.[2] There is some loss on storage, but it is so small that the vitamin C of canned fruits and vegetables, even after prolonged storage, may be more than that of fruits and vegetables bought on the open market and then cooked.

Dehydration. Vegetables and fruits have long been dried as a method of preserving them. Each war revives the scheme for drying vegetables for feeding soldiers on the field. But the use of such dried vegetables has in the past—notoriously in the Civil War in the U.S.A.—been followed by scurvy. During the war 1939–45, by paying due attention to the ascorbic acid oxidase and by excluding air from the "pack," it has been possible to produce a dried vegetable having 60–80 per cent. of the original ascorbic acid. When cooked, such vegetables should retain 25–35 per cent. of their raw value of ascorbic acid, a figure which compares very favourably with those in home cooking.[3] Dehydrated vegetables stored in nitrogen retain their qualities for at least a year.

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[1] OLLIVER. (1943), *Chem. and Ind.*, **62**, 146.

[2] OLLIVER. (1936), *ibid.*, **55**, 153.

[3] ALLEN, BARKER and MAPSON. (1944), *Proc. Nut. Soc.*, **1**, 153.

Physiological Function of Ascorbic Acid. Its use in the body is undoubtedly in the oxidation-reduction systems which play such a large part in metabolism. The ease with which it can be oxidized and reduced suggests that it acts as a hydrogen transporter. Its value in oxidation can be gauged from the fact that cats survive severe hæmorrhages[1] and mice exposure to low oxygen tensions if they have received large doses of ascorbic acid.[2] This is an indication of its importance in aeronautics.

Ascorbic acid aids the body in the detoxication of various toxins, notably tubercle toxin, and is also concerned with carbohydrate metabolism. It is said rapidly to raise the sugar level of the blood after insulin shock. In its absence the cement substance of the capillaries, and the collagen of connective tissues decreases in amount and strength. The capillaries become fragile—hence the proneness to bruising in scurvy—and wounds will not heal; and broken bones will not unite.[3] The later symptoms of scurvy seem all to be related to this poverty of cement and collagen formation, whereas the earlier symptoms—the gloom, irritability and so on—are related to defective oxidation, probably of carbohydrate.

Amount Required per Day. Here we can give as yet no certain decision. In the last edition we suggested that 30–50 milligrammes per day is sufficient, though we by no means suggested that it was an optimal figure. The National Research Council chooses a figure 70 or above for all except children below 10 years of age and even at one year advocate 30 milligrammes! On the other hand, experience of nearly everyone who has investigated the ascorbic acid intake of people in Great Britain during the war of 1939–45 shows that they were "rubbing along" with much less than 70 milligrammes and even less than 30. Fox,[4, 5] of Johannesburg, and his colleagues consider that 15 milligrammes per day protect the majority of people, even those doing heavy physical work, from scurvy, whereas 40 milligrammes is a safer figure. One of us (G. G.) has a patient who needs 200 milligrammes per day to keep his tissues saturated. It may easily be the case that our requirements vary as greatly as our requirements for Calories and protein seem to do, and also our liability to tumble over into scurvy. Fox believes that there is a precipice between non-scurvy and scurvy set at different intakes for each individual. This raises at once the question whether there is a prescorbutic state, a condition of sub-clinical scurvy in which the classical symptoms do not appear but there is a lack of well-being—a dis-ease—due to lack of ascorbic acid. This is very widely held to be the case—in fact it is the fashionable doctrine, with Fox's practically the only voice raised against. If we call the rising ground from the edge of Fox's precipice to the "height of land" which represents the optimal value of ascorbic acid in the diet, prescorbutic and subclinical, then perhaps there is no quarrel with the terms "prescorbutic state" and "subclinical scurvy." But if we call the stage when wounds heal with difficulty and when the subject under observation is easily fatigued, "subclinical scurvy" then we must admit that the stage is a tiny one—at any rate in Fox's Kaffirs, for they were energetic and capable of a great amount of muscular work on a diet with about 15 milligrammes of ascorbic acid per day and of the 400 and more subjects of observation only 12 went over the precipice into scurvy. Crandon[1] submitted himself to a diet totally devoid of ascorbic acid. After 40 days the plasma ascorbic acid had fallen to zero, but wounds healed well 44 days later, there was no subjective weakness till the beginning of the third month, no changes in the gums, no increase of capillary fragility nor lowered resistance to infection. A wound made in the 26th week, however, showed no healing in the subcutaneous tissues though it healed well superficially. Consequently we may admit that Crandon was in a subclinical state, for there were no overt signs of scurvy, in the 26th week of his experiment. Evidence has been accumulating that ascorbic acid is essential for the transformation of the precollagen of healing tissues to collagen.[2] Wounds in the absence of ascorbic acid fail to heal and the scar tissue formed is by no means as strong as in wounds healed in the normal animal. Human cases studied post-mortem after gastro-intestinal operations showed defective production of collagen and it is suggested that in the majority of cases this was due to a lack of ascorbic acid. If this be so, it weakens Fox's case against the use of the term "prescorbutic state" and strongly supports the view that patients about to undergo operation should be saturated with ascorbic acid, and kept after the operation on a regime with large amounts of that vitamin.

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[1] Stewart, Learmouth and Pollock. (1941), *Lancet*, **1**, 818.

[2] Peterson. (1941), *Nat.*, **148**, 84. Perhaps related to this oxidation-reduction mechanism is the newspaper story of two Irishmen who were cured of idiopathic methæmoglobinæmia by ascorbic acid.

[3] See Bourne. (1944), *Proc. Roy. Soc. Med.*, **37**, 512.

[4] Fox and Dangerfield. (1940), *Proc. Transvaal Mine Medical Officers' Association*, **19**, 19.

[5] Fox. (1943), *Journal–Lancet*, **63**, 349.

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[1] Crandon, Lund and Dill. (1940), *New England Med. J.*, **223**, 353.

[2] See Hunt. (1941), *Brit. J. Surgery*, **38**, 436.

The problem remains: what are we to prescribe in the average diet of the average man? Göthlin,[1] using the capillary resistance test, puts the ration per day between 27 and 34 milligrammes. Kellie and Zilva [2] claim that they can saturate the body at so low an intake as 30 milligrammes per day. Harris *et alii*,[3] find that schoolchildren show saturation on the first day after a dose of 55 milligrammes, on the second day with a dose of 40 milligrammes, and on the third day with 25 milligrammes. No one can ask more than that his tissues should be saturated with ascorbic acid. In fact it is by no means necessary to saturate the tissues to have enough—that is to judge by absence of subjective symptoms. So we are inclined to think that, but for a few exceptional people, 30 milligrammes per day is enough to prevent any obvious ill-health. It must, however, be borne in mind that people suffering from severe illness need very much more ascorbic acid than the 30 milligrammes necessary for normal health. Tuberculosis [4, 5] and osteomyelitis undoubtedly, and rheumatoid arthritis [6] possibly, to judge by the urinary secretion, increase the need. Probably, arguing from what we guess of the functions of vitamin C, every fever demands an increase in the vitamin C intake; and any form of enteritis, because of the impedance of absorption, will necessitate a greater supply. In fact in hospital work it is a possibility that a routine examination of the excretion of ascorbic acid in the urine —which should be above 25 milligrammes a day—should be instituted.[7]

Whether we estimate the necessary intake as 30 or 50 milligrammes per day, it will be seen from the following tables that it is not difficult to obtain that amount, using the ordinary foods. Many, *but by no means all*, raw fruits, particularly the citrous fruits and the summer fruits (with the exception of cherries), are useful sources. The autumn fruits, apples, pears, and plums, are almost useless, though Bramley Seedling is a marked exception. Many vegetables, especially those of the cabbage tribe and their near relatives the cresses, are extremely useful. Of animal foods only the liver contains much vitamin C.[8]

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[1] GÖTHLIN. (1937), *Acta Paed.*, **20**, 71.

[2] KELLIE and ZILVA. (1939), *Bioch. Journ.*, **33**, 453.

[3] HARRIS. (1936), *Lancet*, **1**, 1488.

[4] MARTIN and HEISE. (1937), *Amer. Journ. Dis. and Nut.*, **4**, 368.

[5] ABBASSY, HARRIS, and ELLMAN. (1937), *Lancet*, **2**, 181.

[6] ABBASSY, HARRIS, and HILL. (1937), *Lancet*, **2**, 177.

[7] ARCHER and GRAHAM. (1936), *Lancet*, **1**, 710.

[8] MILLS. (1932), *Biochem. Journ.*, **26**, 704.

Before presenting tables of vitamin C contents of foods there are a number of points which must be considered. There are two main ways of estimating vitamin C, (1) the *biological method*, by estimating the power of a food to prevent or cure scurvy in guinea-pigs as compared with pure ascorbic acid, (2) a *chemical method*, usually by estimating the power of a protein-free extract of the food to decolourize a standard solution of the dye, dichlorphenol indophenol blue.

The former method is preferred by all biologists but it is costly and time-taking, whereas the latter needs but accurate pipettes and a microburette, and is quick. It need hardly be said which is the most commonly used.

This colorimetric method has sundry uncertainties apart from the individual factor. There are sometimes other reducing substances present in the food which render the dye colourless. These are estimated, unless special precautions are taken, as vitamin C. They are produced as the result of heat on pectins and carbohydrates and appear in molasses and in fruit juices and dried foods stored for several years under normal conditions. They are also present in parsley, walnuts, especially unripe walnuts, germinated grains, malt extract, beer, cocoa and chocolate. So until older estimations are controlled for the possible presence of these substances they must be accepted with reserve.[1] Further, there is grave variability of the amounts of vitamin C in any one type of food. It may vary with the variety of the species. The farther north rose hips are collected in Great Britain, the more vitamin C they contain.[2] A variety from Russia has ten times the amount of most British hips. The Baldwin blackcurrant has more than the Westwick Choice.[3] Dessert apples have little, as a rule, while cooking apples may have some ascorbic acid. The size of the fruit may influence the amount. Large blackcurrants have more than small, but small peas have more than large.[3] The bigger the tomato the less it has in proportion up to a weight of 40 grammes, and there is much variation from plant to plant, and this variation is inherited. The time of year, the amount of ripening, the type of weather experienced in the growing season, all influence the percentage of vitamin C to be found in fruits and vegetables. Consequently we cannot accept published figures unless we recognize these possibilities of variation and treat them more as indications of the vitamin level to be expected, or wished, than as a statement of fact. Nor should we accept in Great Britain figures for food commodities obtained and analysed outside these islands. Tomatoes grown under the weather conditions prevailing in Great Britain are different as sources of ascorbic acid from those grown in the U.S.A. A banana when submitted to analysis here is a very different fruit from one analysed in the States though both may have come from the same place in the Caribees, and similarly with a green pepper analysed here, or in Hungary or in Louisiana. Each country must prepare its own vitamin tables and give the range of values.

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[1] Wokes, Organ, Duncan and Jacoby. (1943), *Bioch. Journ.*, **37**, 695.

[2] Pyke and Melville. (1942), *Bioch. Journ.*, **36**, 336.

[3] Olliver. (1938), *Analyst*, **63**, 2.

In the following table the amounts are given in milligrammes ascorbic acid for 100 grammes which, as pointed out earlier, is an average allowance of fruits and vegetables. Heavy type indicates useful sources.

FRUITS

Apple, Blenheim Orange	3	Lemon	**14–66**
,, Bramley Seedling	**16**	Lime	**32–58**
,, Cox's Orange Pippin . . .	2	Loganberry	**20–48**
Banana	1–15	Melon, Cantaloupe .	**15–53**
Cherry	3–17	Orange	**16–99**
Currant (black) . . .	**136–353**	,, Juice . . .	**28–89**
,, (red) . . .	**50**	Pear	1–10
Gooseberry	**28–47**	Pineapple	**10–63**
Grape	1–4	Plum	0·5–5
Grape fruit	**26–65**	Raspberry	**30**
Greengage	0·5–7	Strawberry	**46–77**
Haw	**49–500**	Tangerine	**10–36**
Hip	**10–1870** [1]	Tomato	**13–39**

Hips and haws have been included because schoolboys are apt to eat them, and the U.S.S.R. employ them in the manufacture of antiscorbutic for winter use in the Arctic Circle. Moreover, during the war of 1939–45 the Ministry of Food has put rose-hip juice on the market as a source of vitamin C for infants and children. One medium-sized orange weighs about 170 grammes and yields about 70 c.c. juice and therefore from 11 to 62 milligrammes ascorbic acid according to origin. South African oranges have the highest titre of the oranges sold in Great Britain. We call attention to the enormous amount in black currants, and point out the value of these, even when canned, in supplying vitamin C at a time or place where it is difficult to obtain it. During the war the standardization of the purées of black currants used for infants and patients with gastric disorders has been in the hands of Olliver, of Chivers & Sons, who first put the purée on the market.

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[1] The figures given are for British rose hips. Scottish and northern-grown hips have the highest value. Hips from a Turkestan species grown at Kew reached a record figure of 4800. PYKE and MELVILLE. (1942), *Biochem. Journ.*, **36**, 336.

VEGETABLES (RAW) USED AS SALADS

Carrot	4	Onion, spring	14
Celery	1–6	Peppers	12–330
Cucumber	1–18	Radish	12–20
Endive	19	Tomato	13–39
Lettuce	0·5–22[1]	Watercress	24–76
"Nasturtium" i.e. Tropaeolum majus leaves	200–465		

We point out how disappointing carrot, celery and lettuce are, and the possibility of using peppers which are sometimes sold in our big stores in autumn as a source of vitamin C. If people would learn to use raw cabbage and raw brussels sprouts and turnips as salad, the salad sources of vitamin C could be extended and cheapened, e.g.

Cabbage	20–124	Sprouts	72–146
Cauliflower	19–101	Swede	20–47
Green sprouting broccoli	111–141[2]	Turnip	17–43
Kohl rabi	50		

COOKED FRUITS

Currant (black)	90	as normally consumed [3]
Currant (red)	23	
Gooseberry	20	
Grapefruit-juice	34–50	(canned)
Hip	210	(cooked 12 mins., sieved, sugar added, cooked another 4 minutes)
Loganberry	20	as normally consumed [2]
Orange-juice	29–50	(canned)
Strawberry,	solid 10–55, liquid 10–20	

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[1] English mean figure given as 16 by OLLIVER. (1943), *Chem. and Ind.*, 63, 146.

[2] American figures. WHEELER, TRESSLER and KING. (1939), *Food Research*, 4, 593.

[3] Figures from OLLIVER. *Op. cit.*

Cooked Vegetables

Asparagus (green stem),	solid	19–40	(boiled)
„ „ „	„	13–33	(canned)
Beetroot,	„	20	(boiled 1 to 2 hours)
Beet tops,	„	16	(boiled 10 minutes)
Broccoli,	„	22	(boiled)
Cabbage,	„	10–22	(boiled 30 minutes)
Kale,	„	36	(boiled 25 minutes)
„		20	(boiled and then kept hot in hay box)
Potato,	„	4–15	(boiled, peeled)
„	„	4–17	(steamed, peeled)
„	„	7	(fall from 10 after two hours in hay box)
Spinach,	„	30	(boiled 30–40 minutes)
Sprouts,	„	33–44	(boiled 30–40 minutes) [1]
Tomatoes,	„	7–21	(canned)
Tomato-juice		5·4–23	
Turnip,	„	18	(boiled)

The above tables, taken from various sources but mainly from *Nutrition Abstracts and Reviews*,[2] show that it is by no means difficult nor expensive to supply ascorbic acid in the diet the whole year round. Chappell [3] has shown that 30 milligrammes of ascorbic acid could be purchased for one farthing in 1938. Yet we know that the patients in six London hospitals [4] in 1943 were receiving much less than this, and the nurses not much more than the patients. The same is doubtless true of provincial hospitals. And if hospitals can err, how much more likely are school and factory canteens to do the same ? There is little doubt that the diet of the large boarding-schools throughout the winter months give too little of this vitamin, grow too little of the fruits and vegetables which contain this vitamin and present it in a way both unpalatable and devoid of ascorbic acid. Agriculture, market gardening, education and the art of cooking have a long way to go before people in this country take a diet which contains the modest amount of 30 milligrammes of ascorbic acid per person per day.

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[1] Amount falls by a further 50 per cent. or more if kept hot in a hay box.

[2] Fixsen and Roscoe, 1937–8, **7**, 823 ; and Fixsen, 1938–9, **8**, 281.

[3] Chappell. (1940), *Journ. Hygiene*, **40**, 701.

[4] Memorandum on Hospital Diet. (1943), King Edward's Hospital Fund for London.

Vitamin D

That the formation of sound bone and sound teeth is regulated by the supply of a vitamin was first put on a sound scientific basis by Edward Mellanby and his wife May Mellanby.[1] Puppies fed on a diet of skimmed milk, bread, and olive oil developed rickets and their teeth were almost devoid of enamel. This state could be prevented by giving cod-liver oil instead of the olive oil, or in fact many other animal fats though very few (if any) vegetable fats. That rickets in infants could be cured or prevented by cod-liver oil had been recognized by some but by no means all physicians long before, but it was conclusively proved by the commission which visited Vienna in 1919–22 and reported on its work in 1923.[2] That sunlight and ultra-violet light [3] also prevented or cured rickets was confirmed at the same time. The ultra-violet light acting on a sterol in the skin converts it into vitamin D, which passing into the blood stream can prevent the occurrence or promote the healing of rickets. Sterols in foods when exposed to ultra-violet light undergo a similar transformation and become antirachitic. Further, this vitamin was shown to differ from vitamin A, for it was more resistant to oxidation [4] and it was precipitated along with the sterols from the unsaponifiable parts of the fats which carried it. These sterols are complex organic substances and have become of great importance in biochemistry, for their chemical "skeleton" is found in the sex hormones, the suprarenal cortex hormone, some carcinogenetic substances, the "organizer" in the developing egg, bile salts and the cardiac drugs, digitalin and strophanthin.

A sterol found in ergot and in yeast—ergosterol—has an ultra-violet absorption comparable with that of vitamin concentrates which cured or prevented rickets. Ergosterol when irradiated with ultra-violet light cures or prevents rickets.[5] By careful fractional distillation or fractional crystallization of the substances produced by ultra-violet light on ergosterol a substance was obtained which was molecularly pure and cured rickets in exceedingly minute amounts. It was called calciferol and was thought to be "the" vitamin D.[1] Its formula is almost certainly

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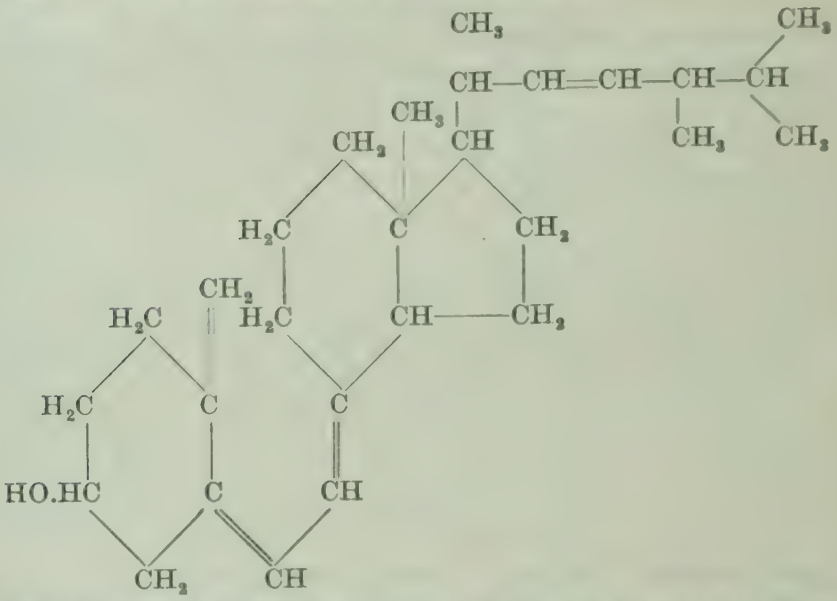
[1] See a series of papers beginning in 1918, *Lancet*, **2**, 767, and continuing in various *Medical Research Council Special Reports*.

[2] *Med. Res. Counc. Special Report*, No. 77.

[3] HULDSCHINSKY. (1919), *Deut. med. Woch.*, **45**, 712.

[4] McCOLLUM *cf al.* (1922), *Journ. Biol. Chem.*, **53**, 293.

[5] WINDAUS and HESS. (1927), *Nachr. d. Wissen. Göttingen*, quoted by McCollum. ROSENHEIM and WEBSTER. (1927), *Lancet*, **1**, 306.



and it is 400,000 times as active in curing rickets as cod-liver oil. But it is by no means the only substance produced from sterols which cures rickets and it is probably not the substance in cod-liver oil which cures rickets. Thus it cures the rickets that occurs in rats but not the rickets from which chickens suffer which, however, is easily cured by cod-liver oil. There may be six or eight forms of vitamin D, some natural, some artificial. The artificial vitamin, calciferol, is often called D_2 and the vitamin of cod-liver oil D_3.

In dietetics it does not matter much what the actual formulæ of the various substances are: what we are concerned with is what they do in the body, how much of them and how long we should take them and in what foods we can find them.

The problem of rickets was by no means solved by the discovery that the calcification of bones and teeth is controlled by vitamin D. Because of the numbers of factors involved in ossification this is not astonishing. If mathematicians cannot solve the problem of the gravitational effects of three bodies one on another it is not difficult to see that the much more complicated interrelation of the factors conducing to rickets demands time, patience and much experiment to unravel. The variables are manifold:

(i) the vitamin D in the diet including the form in which it is presented, whether as D_2, D_3 and possibly in other forms.

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[1] Askew, Bourdillon, Bruce, Jenkins and Webster. (1930). *Proc. Roy. Soc. B.*, **107**, 76.

(ii) the relation of calcium and phosphorus to each other in the diet.
(iii) the relation of calcium and phosphorus to each other in the blood serum and particularly the state of ionization of these elements.
(iv) the influence of the parathyroids in maintaining the constancy of calcium in the blood.
(v) the effect of ultra-violet light, whether artificial or in sunlight.
(vi) the influence of protein and fat in the food.
(vii) the influence of the alkali reserve of the body.
(viii) the effect of exercise.

This long list has not exhausted the possibilities.

Now rickets may occur at all ages. Though once strenuously denied, it is undoubted that fœtal rickets occurs, even in Europe, though first described in China.[1] Rickets usually occurs between the ages of 4 months and 18 months, and spontaneous cure is frequent. But rickets may be delayed till the third and fourth year of life. Renal rickets, which was once denied inclusion under the term rickets, though the bone picture is identical, has now been shown to be true rickets induced by disease of the kidney. Graham and Oakley [2] cured the renal rickets in a boy of sixteen by treatment with alkali to increase the alkali reserve and with doses of 3000 to 6000 I.U. of vitamin D, with exhibition of calcium lactate to increase the calcium intake. Finally the disease osteomalacia is really adult rickets.

Osteomalacia and osteoporosis must be distinguished. Osteomalacia is a softening of the bones due to lack of vitamin D among other factors, such as starvation and lack of mineral elements in the diet, and its characteristic is the presence of osteoid material, the "organic part of bone without the inorganic." Osteoporosis consists essentially of a diminution of calcium phosphate and carbonate in the trabeculæ of the bones. Post-mortem no osteoid material is found.[3]

Rickets is usually a disease of slum life and poverty, but not necessarily so. It appears much more frequently in bottle-fed babies than in breast-fed, though it is not absent in the latter. This is so in spite of the fact that human milk contains much less calcium and phosphorus than cow's milk. A diet overloaded with cereals conduces to rickets.[1] Cod-liver oil has been known to be a specific for nearly a century.[2] Sunlight prevents or cures rickets and this is due to its ultra-violet light.[3] Rickets is a "disease of darkness" whether the darkness be due to Purdah as in India, to smoky cities, or to northerly climates. (In Glasgow smoke and deficient ultra-violet light in the northerly sunshine are combined.) Artificial ultra-violet light is efficacious in curing rickets.[4] Rapid rate of growth produces worse rickets than slow.[5] Fats are useful and not only because of their content of vitamin D, though a diet very rich in fat may induce rickets.[6] Cœliac disease, because of the patient's difficulty in absorbing fats and their contained vitamin D, is almost invariably accompanied by rickets. Children with rickets often show an acidosis.[7] Acidity of the small intestine antagonizes rickets. Vitamin D prevents or cures rickets, D_3 being more useful than D_2.[8] One large dose, say 100,000 I.U. given parentally, is as valuable as small daily doses by mouth.[9] Idiopathic tetany in children is always accompanied by rickets, though rickets is by no means always accompanied by tetany.[10] The serum of rickety children may have a normal calcium value (8–10 milligramme per 100 c.c.) whereas the phosphorus is always below the normal.[11] There is often parathyroid hypertrophy in rickets,[12] and generally speaking the parathyroids are enlarged in northerly climes. The blood phosphatase is increased in rickets.[13] While vitamin D cures rickets, parathormone makes it worse.[14]

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[1] MAXWELL. (1930), *Lancet*, **1**, 454, and *Proc. Roy. Soc. Med.*, **33**, 639.

[2] GRAHAM and OAKLEY. (1938), *Arch. Dis. Childh.*, N.S., **1**, 1.

[3] BURROWS and GRAHAM. (1945), *Quart. J. Med.*, **38**, 147.

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[1] Trousseau. (1865), *Clinique Medical del' Hôtel Dieu de Paris.* Second edition. Quoted by Bicknell and Prescott. (1942), *The Vitamins in Medicine,* 452.

[2] Trousseau. *Op cit.*

[3] Huntly (1889), and Palm (1890), quoted by Howland. (1923), *Medicine,* **2**, 349; Chick *et al.* (1923), *Studies of Rickets in Vienna*; (1919–1922), *Med. Res. Counc. Rep.,* 77.

[4] Huldschinsky. (1919), *Deut. med. Woch.,* **45**, 712.

[5] Bicknell and Prescott. (1942), *op. cit.* See also Mellanby. (1921), *Experimental Rickets. Med. Res. Counc. Spec. Rep.,* **61**, 33.

[6] Booth, Henry and Kon. (1942), *Biochem. Journ.,* **36**, 445.

[7] Hodgson. (1921), *Lancet,* **2**, 945.

[8] May, Wygant *et al.* (1939), *Arch. Pæd.,* **56**, 426. Quoted by Bicknell and Prescott, *op. cit.*

[9] Krestin. (1945), *Brit. Med. Journ.,* **1**, 78.

[10] Howland. (1923), *Medicine,* **2**, 349.

[11] Howland. (1923), *op. cit.*

[12] Pal. (1937), *Ind. Med. Gaz.,* quoted by Bicknell and Prescott, *op. cit.*

[13] Morris. (1937), *Lancet,* **1**, 87.

[14] Bicknell and Prescott, *op. cit.*

Experimental results upon animals agree with clinical observations as regards cereals, cod-liver oil, sunlight, ultra-violet light, acidity of the gut, high calcium low phosphorus in the serum, phosphatase of the serum and the efficacy of vitamin D. It has added that vitamin D_2 (calciferol) while useful for man and rat is useless for chicken;[1] that metals such as beryllium,[2] which form insoluble phosphates produce rickets; the relation of calcium to phosphorus in the diet is important, for both high calcium-low phosphorus and low calcium-high phosphorus diets conduce to rickets in the rat, and when that ratio is 4 : 1 or 1 : 4 the animal needs increased doses of vitamin D to ward off rickets.[3] Finally, experimental work on puppies has explained the cereal effect on rickets.[4] As will be indicated in the section on the milling of cereals (pp. 308–17) the phytates render some of the calcium of the diet insoluble and so produce a low available calcium-high phosphate chyme.

The *causa causans* of rickets is a lowered intake of vitamin D or a lowered manufacture of that vitamin by the action of sunlight or rather by the ultra-violet light the sunlight contains. How it brings about the action is still a moot point.

Here we meet a discrepancy between the views of clinicians and the experimentalists. The clinician, because of the fact that the calcium of the blood may be normal in rickets, while it is the phosphorus which is lowered, look upon human rickets as high calcium-low phosphorus rickets. The experimentalists, particularly those working upon puppies, look upon rickets as due to a low calcium-high phosphorus diet in the absence of sufficient vitamin D or ultra-violet light. Nutritional surveys support this view, for while poverty restricts the calcium intake it rarely reduces the phosphorus intake to a dangerous level.[5] All agree that lack of vitamin D—or of sunlight or ultra-violet light—is the all important factor in correcting the disturbed calcium or phosphorus metabolism. How does it act?

First of all its effect is catalytic. When as little as $0{\cdot}025\gamma$ can show its effect in a rat weighing 400,000,000 times as much, its effect must be catalytic. But where does it act ? In controlling the uptake of phosphorus from the gut ; in influencing the alkali reserve ; in retention of phosphorus in the body ; in keeping the ionizable calcium of the blood constant via the parathyroid ; in holding the phosphorus in the blood and tissue fluids in a particular form ; in keeping the calcium phosphate-calcium carbonate complex in the blood in a supersaturated state ; or directly, in governing the deposition of calcium phosphate in the osteoid tissue ? We do not know as yet. It will need much further research to elucidate the problem.

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[1] Müssehl and Ackerson. (1930). Quoted by McCollum, Orent-Keiles and Day, *op. cit.*, 340.

[2] Jones. (1938), *Am. J. Physiol.*, **124**, 230.

[3] McCollum, Orent-Keiles and Day. (1939), *The Newer Knowledge of Nutrition*, 173 *et seq.*

[4] Harrison and Mellanby. (1939), *Biochem. Journ.*, **33**, 1660; Bruce and Callow. (1934), *Biochem. Journ.*, **28**, 517.

[5] McCance and Widdowson. (1938), *Journ. Hygiene*, **38**, 596; Widdowson. (1945), personal communication.

All this may appear academic to the dietitian. It is fairly clear that a low calcium intake compared with the phosphorus intake plus a low vitamin D intake conduce to rickets and the problem is to increase both. Milk, cheese and fish are indicated as increasing the calcium intake without at the same time overincreasing the phosphorus intake, and the vitamin D by increasing the intake of the few foods which contain vitamin D or by use of fish-liver oils as a prophylactic. How much vitamin D is essential for the normal child and adult is still uncertain.

As regards the cure of, or protection from, rickets, it is fairly certain that 500 I.U. per day form a satisfactory dose. (The unit is the vitamin D activity of 1 milligramme of the standard solution of irradiated ergosterol and equals the activity $0{\cdot}025\gamma$ of crystallized calciferol.) This is the dose for a child. How much is essential for an adult is not known. A problem still unsolved is why so many children show no obvious signs of rickets though their daily intake of vitamin D must be well below the level of 500 I.U. Mild rickets occurs in many babies, but we should expect it to be much more obvious if this figure is near the minimum. Idiosyncracies of absorption of calcium, phosphorus and vitamin D and utilization of these essential factors may be the explanation or varying exposure to sunlight. Diarrhœa and dosage with liquid paraffin may impede absorption.

Another problem is how long this intake of vitamin D should continue. Almost certainly it should start before birth. There is evidence from China, from America, and Scandinavia that the bones of the new-born are better calcified if the mother has had adequate doses of calcium and vitamin D during pregnancy. The formation of bones and teeth starts before birth and continues till the last teeth are erupted, which may be not till 18 to 21. It is true that the usual age for rickets is 6 months to 18 months, but it will be remembered from the above that there are such diseases as renal rickets, fœtal rickets [1] and delayed rickets, and that delayed rickets shades off into osteomalacia, which is really adult rickets. At the least—for osteomalacia is more frequent with women—extra vitamin D should be taken by women as long as child-bearing continues.

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[1] MAXWELL. 1930, *Lancet*, **1**, 454 ; and (1930), *Proc. Roy. Soc. Med.*, **23**, 639.

Calcium deposits can be organized up to old age and presumably in their organization vitamin D is needed; and, moreover, vitamin D[1] aids in averting caries and there is no age at which caries does not attack the teeth. Consequently there is every reason for including vitamin D in the diet at any age, and for want of a better figure we may take the 500 I.U. necessary for children as the dose for an adult. Doubtless it will take years for the shortage of vitamin D, to which every adult in Great Britain has been subjected during the War, to show its effects. But there is no reason for saying that the adult needs none. We have the experience of Vienna after the first World War, when osteomalacia was of common occurrence, as a warning against complacency of that kind.

It has long been known that the skin condition lupus vulgaris can be greatly improved by means of the Finsen lamp. This produces ultra-violet rays and will therefore aid in the formation of calciferol in the skin. It has now been shown that large doses of calciferol by mouth causes, after an initial deterioration, great improvement and healing of the skin lesions. The doses given are 150,000 I.U. daily, which with care do not cause any ill effects.

There are extraordinarily few foods which are sources of vitamin D apart from fish-liver oils. There are the fat fish and the body oils of the eel, herring, and sardine have 4700, 10,000, and 8000 I.U. per 100 grammes respectively,[2] and counting the oil as about 10 per cent. of the flesh, we get 470, 1000 and 800 I.U. per serving of these fish. Fresh herrings caught off the shores of Great Britain in 1941–42 contained from 84–479 I.U. per oz. in the flesh or approximately 300–1170 I.U. per 100 grammes. Canned herrings have about $\frac{1}{5}$ of this amount.[3] Canned salmon contains from 200 to 800 I.U. per 100 grammes (about 3½ oz.); the red salmon having the highest value.

Milk has from 0 to 10 units per 100 c.c. of vitamin D or 0 to 57 units per pint.[4] (The higher figure is for summer milk.) Winter butter has approximately none while the summer figure may be as much as 113 per oz. The average figure is 34 per oz. New Zealand butter may have nearly 90 per oz. Eggs may yield 22–75 per egg according to the feed of the hen. Dairy foods are a disappointing source of vitamin D.

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[1] May Mellanby. (1944), *Brit. Med. Journ.*, **1**, 837.

[2] Fixsen and Roscoe. (1937–8), *Nut. Abs. and Rev.*, **7**, 823.

[3] Bacharach, Cruickshank, Henry, Kon, Lovern, Moore and Morton. (1942), *Brit. Med. Journ.*, **2**, 691.

[4] Cows fed on cacao shells secrete a milk with a higher vitamin D content. Knapp and Coward. (1935), *Biochem. Journ.*, **29**, 2728.

Of course foods could be fortified either by the addition of concentrates, as all margarine in this country was fortified during the war to the extent of 57 I.U. per oz., or by irradiation with ultra-violet light, as is done in the United States. Fortification of margarine is compulsory in Scandinavia. Yeast and milk lend themselves to irradiation. Otherwise we must rely upon fish-liver oils and treat them not as a medicine but as a food.

The chief liver oils used—cod-liver and halibut-liver—contain very large amounts ; the only other which can compete commercially with them is the tuna-liver oil. Cod-liver oil has a vitamin D value of 60 to 300 I.U. per gramme and an average figure is 100 I.U. per c.c. To obtain the best oil, the cod-liver should be extracted as soon as the fish is caught and kept out of contact with air till it reaches the refinery ; the oil so produced has a much higher vitamin D value—e.g. 300 or more I.U. per c.c. : 4 c.c. of the weaker oil and 2 c.c. of the stronger at a cost of one halfpenny to one penny per day will cover the vitamin D needs of anyone.

The figures for halibut-liver oil are much higher, viz. 200 to 4000 per gramme and consequently still less is needed—in the case of the stronger oils but a few drops per day.

The trouble is that except to the modern child brought up to take fish-liver oil from its first month these oils are distasteful.[1] This may be because the oil has been carelessly administered or allowed to become oxidized or given in too large amounts, but it is unfortunately true. It is usually necessary to give adults the concentrated oils in the form of capsules, which adds to the cost.

We are therefore in a somewhat difficult position. Few foods have vitamin D in them except fish-liver oils and many people dislike fish-liver oils so much that they refuse to take them. They can, however, be introduced into fish sauces, mayonnaises, soups, potted fish, and savouries, and this method of overcoming the difficulty has been taken up by colleges of Domestic Science and numerous recipes produced.[2] It is astonishing that cod-liver oil introduced into gingerbread cannot be tasted. There is no reason to believe that the vitamin D so introduced into fish sauces and other dishes loses any of its virtue in the process of cooking.[3] A first-rate cod-liver oil costs about the third of the price of salad oil and can be recommended in making a salmon mayonnaise on the grounds of economy.

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[1] Those rendered as soon as the fish is caught and not allowed to oxidize in the process of manufacture taste least.

[2] LINDSAY and MOTTRAM. (1939), *Brit. Med. Journ.*, 1, 14.

[3] FIXSEN. (1938–9), *Nut. Abs. and Rev.*, 8, 281.

Fortunately, severe rickets is almost a thing of the past in Great Britain, though not in Ireland; and mild rickets has decreased remarkably, probably as a result of the work of child welfare centres. Dentition in this country, to judge from general observation and specific investigation,[1] is on the upgrade, though there we have a long way to go before we reach the standard of the American and Canadian soldiers we entertained during the war of 1939–45.

Vitamin E

It has long been known that there is another fat-soluble vitamin essential for reproduction in the rat. In its absence the male becomes permanently sterile while the female, though she conceives, cannot bring the fœtuses to birth—they are reabsorbed by the placenta. None the less, if put upon a diet containing the vitamin, she can thereafter successfully raise a family. The vitamin is found in greatest amounts in wheat oil, though it is widely distributed in green foods and in milk. Two alcohols, α- and β-tocopherols, have this vitamin E action.

The majority of the human race do not suffer from any particular lack of this vitamin but it is possible that some women need much greater amounts than others to carry through a successful pregnancy. There is suggestive evidence that habitual abortion responds to the exhibition of doses representing about 5 grammes of wheat oil during pregnancy,[2] but not all obstetricians are converted to that view.[3] It is held by one professor of medicine that good advice to the habitual aborter is as efficacious as a course of vitamin E concentrate. This does not, however, explain the success which Vogt-Møller claims in veterinary practice. At any rate the problem of the prevention of habitual abortion is more medical than dietetic and will be treated, if the vitamin E hypothesis holds, rather by giving a concentrate of the vitamin than by a diet rich in vitamin E. It is difficult to give a diet satisfactory for vitamins A, B, C and D without giving vitamin E at the same time.

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[1] May Mellanby. (1944), *Brit. Med. Journ.*, **1**, 837.

[2] Vogt-Møller. (1931), *Lancet*, **2**, 182; (1933), *Acta. Obst. et Gynœc. Skand.*, **13**, 219; (1936), *Klin. Wockenschr.*, **15**, 93; Watson. (1936), *Can. Med. Assoc. Journ.*, **34**, 134; Watson and Tew. (1936). *Amer. Journ. Obst. and Gynœc.*, **31**, 352; Currie. (1937), *Brit. Med. Journ.*, **2**, 1218.

[3] *vide* a discussion held by the Food Group of the Society of Industrial Chemists, April, 1939.

Other Vitamins

As research continues, it is highly probable that more vitamins will be discovered and that later these will be shown to be important for man. Many have been discovered or postulated for this or that animal and it may be that one or another will prove to be indispensable in human nutrition. One such vitamin—**Vitamin K**—known to be important in the feeding of chicks, sprang into a position of more than theoretical importance late in 1939.[1] It was shown by Dam that a number of infants with a syndrome of symptoms including jaundice, hæmorrhage and dropsy, had a reduced clotting-power of the blood. In chicks suffering from a lack of this vitamin the resulting diminished power of coagulation of the blood is due to a lack of prothrombin, and feeding them with vitamin K restores to the animals their power of making prothrombin.

Further, four adults were shown by Dam to be deficient in prothrombin as the result of a lack of this vitamin. Three had scurvy and one pellagra ; therefore their diet was highly deficient in ascorbic and nicotinic acids. All had a low prothrombin level which became normal 24 hours after treatment with vitamin K. Low prothrombin levels have been observed in patients suffering from obstructive jaundice, sprue, biliary fistula and ulcerative colitis—diseases in which there is either a lack of bile salts in the alimentary tract or poor absorption.

There are two naturally occurring substances which restore to the blood its lost power of clotting, (i) vitamin K_1, or 2-methyl-3-phytyl-1 : 4-naphthoquinone, and (ii) vitamin K_2 or 2-methyl-3-difarnesyl-1 : 4-naphthoquinone. The first is found in green vegetables, e.g. cabbage, spinach, green peas, alfalfa or lucerne, but not in fruits or cereals ; the second is manufactured by bacteria including those living in the gut.

Both these naphthoquinones are soluble in fat and fat solvents, but are insoluble in water. Consequently the body has difficulty in absorbing them when there are no bile salts in the gut or in other cases (e.g. sprue) when the absorption of fat is deficient. Medicinal paraffin oil impedes the absorption of vitamin K.

Commercial 2-methyl-1 : 4-naphthoquinone is even more active than the natural vitamins and though mildly toxic is replacing them in therapy.

It will be clear from the above that the normal person eating a mixed diet including green vegetables is never likely to suffer from a lack of vitamin K. Even in the absence of these vegetables he can rely on the microbes in his large intestine to manufacture a sufficiency. But if his powers of absorption of fat are lowered or his intestinal flora depressed by a long course of sulphonamides he may suffer from a deficit. Babies when born have a sterile gut and it takes two or three days to establish therein a good bacterial flora. If then the mother's diet has been deficient in K_1 or her absorption of K_2 from her colon been poor, the baby is born with a lowered prothrombin titre of its blood. Hæmorrhagic disease of the newborn is often attributed to lack of vitamin K, and the Scandinavian school of obstetricians and pædiatricians use vitamin K as a prophylactic.[1] American data are not so encouraging.

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[1] DAM. (1939), *Lancet*, 2, 1157 and 1162.

In dietetics vitamin K is not important because a diet satisfactory for the earlier discovered vitamins, particularly A and C, will most probably contain K.

Vitamin P

In the section on vitamin C above, ascorbic acid and that vitamin have been equated. If, however, vitamin C is defined as that vitamin which wards off *all* the symptoms of scurvy then vitamin C activity includes more than the activity of ascorbic acid. One of the symptoms of scurvy is the formation of petechiæ, small extravasations of blood under the skin. These can be produced artificially by suction over a small area of skin and the negative pressure under which petechiæ appear measured. In scurvy it takes a much smaller tension (or negative pressure) to produce petechiæ—i.e. the resistance of the walls of capillaries to tension from without, and presumably pressure from within, is lowered. Now according to the majority of workers who have investigated it, this lowered capillary resistance is not due to lack of ascorbic acid in the diet but of another vitamin.[2] Szent-Györgyi, who first called attention to this, considered that it was the capillary **permeability** which had been altered, not its fragility, and so called the vitamin, vitamin *P*. He first related this vitamin activity to hesperidin, a flavone occurring in orange peel and pulp, but later he considered that the active substance was eriodictiol which is not easily separated from the hesperidin. Later workers have prepared a water-soluble substance which has 100 times the activity of recrystallized hesperidin and is active at the microgramme level rather than the milligramme.[3]

Vitamin P occurs alongside of ascorbic acid in many fruits and

[1] LEHMANN. (1944), *Lancet*, **1**, 493, 506, and **2**, 737.

[2] Rats can suffer from the absence of this vitamin, but can manufacture ascorbic acid.

[3] BACHARACH and COATES. (1942), *Analyst*, **67**, 313.

vegetables, but they are not present to the same extent.[1] It is true that the water-soluble extract having the greatest amount comes from black currants which have large amounts of ascorbic acid, but plums and prunes which have practically no ascorbic acid are rich sources of P.[2] Generally speaking, vitamin P is much more widely distributed than ascorbic acid but the range of values is not so great. Even dried peas have some. Moreover fruits, roots and salad plants, apt to be neglected because of their low content of ascorbic acid, have reasonable amounts of vitamin P. For example we mention blackberries, cherries, grapes, plums and prunes; also carrots and lettuce. So that in practical dietetics it comes to this: a diet containing a fair amount of fruits and vegetables will contain a satisfactory amount of vitamin P. Rich sources of vitamin P include apples, blackberries, blackcurrants, cherries, grapes, lemons, oranges, plums and prunes among fruits, and cabbage, cauliflower, lettuce, parsnip and spinach among vegetables. Tomatoes, too, are satisfactory.[3] As far as figures are available it is seen that if ascorbic acid is provided by means of natural foods vitamin P will also have been provided.

Meanwhile, vitamin P concentrates have proved useful in treating purpura and various hæmorrhagic conditions of stomach, kidney and lungs.

However important in science and medicine the vitamins discovered in the future may prove to be, it is unlikely that such discovery will make much difference to the principles and practice of dietetics. The more recently discovered vitamins were discovered only because the earlier vitamins had been isolated and purified; and of course, generally speaking, the more widely distributed and easily isolated vitamins were the first to be isolated and synthesized. If the physician is treating deficiency diseases with vitamins he should use a blunderbus preparation of all the known vitamins, for deficiencies are rarely single but multiple. Now a mixed dietary, containing dairy foods, fruit and vegetables, fish and whole cereals is a blunderbus diet. It contains all the known vitamins and probably all the unknown vitamins as well; whereas a blunderbus vitamin concentrate may, and probably will, exclude the undiscovered ones.

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[1] Bacharach and Coates. (1943), *Journ. Soc. Chem. Ind.*, **62**, 85.

[2] Scarborough (1941), *Proc. Bioch. Soc.*, July 18.

[3] These statements are based upon work by Scarborough on man and on preliminary reports by Geoffrey Bourne, which we have been privileged to see. See also Bacharach and Coates upon guinea-pigs, *op. cit.*, and Scarborough. (1941), *Chem. and Ind.*, **60**, 618.

CHAPTER VI

PRACTICAL ASPECTS OF KNOWLEDGE OF CALORIES, PROTEINS, MINERAL ELEMENTS AND VITAMINS

It is time to sum up the facts and evidence put forth in Chapters II to V and to show as briefly as possible how an optimal diet may be obtained. To quote Sherman: sound diet stands four-square upon Calories, proteins, " mineral " elements and vitamins. Each group is important and each member of each group is important, and in its absence the body sooner or later dies. Perhaps the importance of water should be emphasized as well. The body, as has been said above, lasts some 4 to 5 days only without water, some 50–70 days without Calories and protein, and much longer without most of the mineral elements and the vitamins.

The average man, and indeed the average dietitian, cannot carry around in the memory the mass of facts which have been adduced about the Calorie value, the percentage composition, the mineral element and the vitamin values of the multitudinous foods which appear even in a modest diet. Nor is it at all necessary that such data should be memorized. That way a sort of madness lies and an overweighting of some food or type of food dear to the heart of the particular dietitian. (Years ago Langdon Brown said that the likes and dislikes of a physician could be gauged by what he allowed—or forbade—his dyspeptic patients to eat.) Interest in this or that vitamin or mineral element often hides an interest in this or that food. All that is necessary is to group the foods in the simple plan already laid out on p. 17.

It will be seen, from the four preceding chapters, that foods which are most important for Calories come mainly from the grocer and baker; those for protein come from the dairyman, the butcher and the fishmonger; while those which supply the mineral elements and the vitamins come from the dairyman, the greengrocer and the fishmonger. Sundry foods recur again and again on the lists.

For example, milk appears as a source of first-class protein, of calcium and phosphorus, of vitamins A and to a smaller extent of the vitamins riboflavine, nicotinamide, ascorbic acid and, in summer, D. It is moderately useful in supplying Calories—as good as potatoes. Cheese and other milk products also are valuable in similar ways—cheese and butter yield many Calories too. Eggs add iron to the good qualities of milk but are a dear source of Calories. Herrings and the fat fish generally are useful for protein, calcium, phosphorus, iodine, vitamins A and D, riboflavine, and nicotinic acid. Nor are they to be despised as sources of Calories. In fact the enquiring mind is driven to assume as fact the great importance of the dairy foods and fat fish in the diet. Nor is he allowed to forget the market-garden produce—the vegetables for vitamins A and C and for iron and possibly calcium, the summer fruit for vitamin C, most fruits for vitamin P and the imported citrus fruits, also for vitamin C.

Perhaps the matter may be displayed in tabular form.

1. Foods for Calories.		Dripping, frying fats, suet, butter, margarine, bacon, cheese, flour, bread, cakes, biscuits, sugar, dried fruits, jam, golden syrup, treacle, potatoes.
2. Foods for Protein.		Milk, eggs, meat, fish, cheese.
3. Foods for Mineral Elements	Calcium.	Cheese, fat fish, milk, eggs.
	Iron.	Eggs, green vegetables, liver, and cooked meat.
	Iodine.	Fish from the sea, seaweeds.
4. Foods for Vitamins	Vitamin A.	The dairy foods, green and yellow vegetables, liver and tomatoes.
	Thiamine.	Yeast, wheatgerm, liver, kidneys, pork, bacon and ham, whole cereals, wholemeal and wheatmeal bread.
	Riboflavine.	Yeast, wheatgerm, liver, skimmed milk powder, cheese, fish and milk.
	Nicotinic acid.	Yeast, fish, meat offal, wheatgerm, meat.
	Ascorbic acid.	Summer fruits, citrus fruits, green vegetables, liver, a few roots of the cabbage and tomato tribes.
	Vitamin D.	The fat fish and summer milk and butter.

Now leaving on one side for the moment Calories and protein and turning to the mineral elements and the vitamins we can group them roughly as follows:

(i) Dairy foods, i.e. milk, butter, cream, cheese and eggs (and "war-time" margarine).

(ii) Greengroceries, i.e. " greens," carrots, swede, turnip, radish, tomatoes, summer fruit, citrus fruits.
(iii) Sea produce, i.e. fish, particularly the fat fish, shell-fish and seaweeds.
(iv) Whole cereals (but with these much dairy food and greens must be taken to outweigh the deleterious effect of the cereal phytates on the intake of calcium and iron).

In Great Britain the diet on the whole has been satisfactory in the past as regards Calories. Only the " submerged tenth "—far too large a proportion—have not had enough Calories. (In India, however, 30 per cent. fail to attain even sufficient Calories.) On the whole, too, the diet has been satisfactory as regards protein, though perhaps not for first-class protein. It is in the dairy foods, the greengroceries, the sea produce and, possibly, in the whole cereals that the diet has been deficient. The reason is partly cost, partly defective transport, partly lack of education and partly poverty. Poverty does not directly explain the refusal to eat whole cereals and rice, except that poverty prevents people from buying milk and vegetables which are essential if whole cereals are taken to any large extent.[1]

These foods which we have listed, (i) to (iv) above, have received the name "*protective foods*." The term originated with McCollum who first applied it to milk and green leaves which protect rats from the deleterious effect of an exclusively cereal diet. Then in time it was extended to all foods which contain the necessary mineral elements and vitamins in any considerable amount; and the term has received the blessing of most dietitians.

It is easy to criticize it. It is unscientific and untrue. All food protects you against hunger, and death in 50 days. Water protects you against death in four days. You can carry on for months without a reasonable supply of calcium, iron, iodine, vitamins A, C and D in your diet as Marrack points out. Moreover, the term has given rise to the expression " protected " food, meaning a food which has not had its vitamins destroyed by processing or cooking. Wholemeal is sometimes described as a " protected food." This is as reasonable as calling an army with machine-guns and no heavy artillery, tanks or air force " protected." Probably the best usage of the term " protective foods " is in the sense of the foods which protect the layman from making a dietetic fool of himself. The term is a useful one though unscientific and it has a great value for propaganda purposes. It is because the diet of Great Britain, and indeed most other countries, needs improvement by the addition of just those foods that the term "protective foods" is retained. It should encourage politicians and agriculturists and the city folk to the spending of thought, time, energy and money on the correct feeding of the nation. The supplies of dairy foods, market-garden foods and fish should be at least doubled, and with the climate, soil and position of the British Isles that should easily be possible. It is a policy which would make for the health of the townsman and the economic health of the nation. The market is here at the door and the problem of getting the goods fresh to the table is one of co-operation, transport, refrigeration on the way and in the home—problems by no means insoluble.

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[1] Sir Edward Mellanby has maintained that it was a wise " instinct " which kept the poor off wholemeal bread.

Given a supply of fresh "protective" foods, of groceries, bread, confectionery, and meat, how should an optimal diet be constructed? There are two ways. We can start right from the beginning, making away with all the schedules of menus we have had in the past; or we can take those schedules and by criticizing them in the light of knowledge of the "protective" foods, amend and bring them up to modern dietary standards. Probably the latter will be the more popular and certainly more British way of solving the problem. Either plan followed wisely will produce much the same result. One produces a safe diet, the other makes the diet safe.

The radical plan, i.e. going to the root of things and altering thence upwards, consists in (i) getting first of all a sufficiency of the "protective" foods or, if you prefer it, the foods rich in mineral elements and vitamins, (ii) second, in supplying foods with first-class protein in them and (iii) making up Calorie needs from the foods which are mainly used to supply Calories.

Let us take an example, at the moment of writing impossible of fulfilment because of post-war conditions, but easily possible with a planned agricultural and food policy in the near future.

Protective foods.
- Dairy foods: Milk, 1 pint. Cheese, 1 oz. Butter, 1½ oz. Egg, 1 per day.
- Greengroceries: 4 oz. tomatoes and 3½ oz. green vegetables or carrots per day.
- Fish: 1 lb. of herrings per week.
- Wheatmeal bread: 8 oz. per day.

These work out as follows, taking average figures from the tables:

	Calcium. mg.	Iron. mg.	Vit. A. I.U.	Thiamine. γ or μg.	Riboflavine. γ or μg.	Nicotinic Acid. mg.	Ascorbic Acid. mg.	Vit. D. I.U.
Milk : 1 pint . .	680	0·0	400	260	965	0·6	6	28
Cheese : 1 oz. .	230	0·2	369	9	47	—	0	—
Butter : 1½ oz. .	12	0·0	1704	0	2	—	0	41
Egg : 1 . . .	30	1·5	500	75	200	—	0	22
Tomatoes : 4 oz..	12	0·4	964	56	57	0·6	24	—
Greens : 4 oz. .	46	0·7	210	50	45	0·3	15	—
Herrings : $2\frac{2}{7}$ oz.	41	0·7	64	4	65	1·9	0	192
Bread : 8 oz.. .	128	4·0	0	424	68	2·0	0	—
Total . .	1179	7·5	4211	878	1449	5·4	45	283

And, in addition to the above, the diet so far as prescribed has nearly 60 grammes protein of which 38 is animal protein, 77 grammes fat and 147 grammes carbohydrate, and yields over 1500 Calories, i.e. on the score of protein and Calories it is sufficient for *some* women.[1] It is already safe as regards calcium, vitamin A and ascorbic acid, but is still a bit doubtful in iron, thiamine, riboflavine and nicotinic acid and possibly in vitamin D.

Very few people would be satisfied with the animal protein of such a diet and would want to add, say, 2 oz. bacon and at least 2 oz. meat a day. If these are added the diet has 73·6 grammes protein, 1854 Calories, and 10 milligrammes iron ; the thiamine has reached 1·2 milligramme, the riboflavine 1·8 milligramme and the nicotinic acid 13 milligrammes. So that by now, although the figures for the iron and vitamins have not reached the levels recommended by the National Research Council of the U.S.A. the diet is deficient practically only in Calories. There is a leeway of 1200 to make up if we are aiming at 3000 and this can be done in any way which is convenient, agreeable or economic. In peace-time probably more fats would be used. In war-time more bread or flour. Potatoes up to 8 oz. a day might be eaten. Jams, golden syrup, honey and treacle might be used as spreads or in cakes and puddings. Sugar too would add to the Calories, though to nothing else. The middle classes would certainly take more meat and add fruits and salads. There should be no difficulty in making the diet completely satisfactory by a wise choice among the foods chosen to make up the deficit in Calories.

The other line of approach to the solution of obtaining a satisfactory diet is to take the normal diet to which the person to be fed is accustomed and to amend it by including the foods given above under the heading of protective foods.

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[1] WIDDOWSON and McCANCE. (1936), *Journ. Hygiene*, 36, 294.

For example, the following is a day's menus from a boarding-school :

Breakfast . .	Porridge, bacon, half a fried tomato, bread and butter, marmalade. Tea.
Mid-morning snack .	⅓ pt. milk.
Dinner . . .	Cold roast beef, mashed potatoes, pickles, rice pudding, bread.
Tea. . . .	Brown and white bread and butter, small cake or scone. Tea.
Supper . . .	Bread and butter, baked beans on toast, and a biscuit. Water.

We can be fairly certain that this diet will be adequate as regards Calories and first-class protein, especially if, as is fortunately common in peace-time in boarding-schools, second helpings of meat are allowed and bread, butter and jam are *ad lib.* But when we scrutinize the diet for the protective foods we begin to wonder if it is adequate.

The dairy foods are represented by milk and butter only. The boys may be getting one pint of milk a day, but it is doubtful. It would be much sounder to supply milk to drink at breakfast and supper, or if the pupils think milk to be babyish, milk with a "dash of coffee." Cheese is completely neglected on this day, and, as a matter of fact, was neglected on nearly every other day of the week.

The market-garden foods and special fruits are also absent except for the half of a fried tomato. To amend this diet it would be well to replace the pickles of dinner with a salad of tomatoes, water-cress, or mustard and cress, or if by carrots—which go quite well with cold roast beef—then later in the day an orange, or lemonade made with fresh lemons should be given, or some fresh or canned summer fruits.[1]

The remaining meals are practically devoid of protective foods except that some brown bread is provided ; but there is no adequate source of vitamin D anywhere in this day's menu. Nor did much appear anywhere else in the week under consideration. Instead of the baked beans, herrings, kippers, bloaters or soft roes on toast might well appear, or a white fish dish with a sauce fortified with vitamin D in cod-liver oil (see p. 182).

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[1] It is amazing how infrequently fruit appears in the diet of people in this country. Of course, fruit is dear and scarce. But it is conceivable that school gardens, at any rate, could grow bush fruits. The dietitian of an institution should have the chief say in what should be produced in the garden.

Most middle-class diets which are adequate as regards Calories and first-class proteins can easily be made satisfactory in all directions by the replacement of some of the foods served by those in the four classes of protective foods listed above. All classes must be well represented. This method of obtaining a satisfactory diet involves but the simplest knowledge of dietetics and moreover avoids the one-sided fanaticism which insists on, say, potatoes boiled in their skins, the use of the water vegetables are boiled in, or the exclusive use of unmilled cereals, which, though they may solve the problem of sound feeding in one direction, completely omit to solve it in others.

CHAPTER VII

THE PROCESSING AND STORAGE OF FOODS

One of man's greatest difficulties in preserving himself alive on this planet has been the alternation of glut and famine due in early history to the flux of the seasons and the uncertainty of the weather, and now due, in addition, to the economic and political systems under which he subsists. Man's endeavour has been to use the surplus of the glut to provide food in time of famine. The storage of food is the beginning of capitalism, and the first large-scale storage of food recorded, in Egypt under the foresight of Joseph, a Jew, the beginning of state capitalism. Man wants to make food keep.

Now there are some foods which, with a little care, can be made to keep for years. These are the cereals, and it is not astonishing that civilization has grown up round the centres of cereal production, for this and for other reasons to be developed later in this book. Cereals stored in the dry and protected from the inroads of insects and rodents will keep almost indefinitely. The plant has used " dehydration " to preserve its means of propagation from one season to the next. Probably, therefore, cereals were the first things to be stored from one year to the next. Other seeds, such as the pulses, also can be kept almost indefinitely.

Protein-containing foods, especially the prized meat, poultry and fish, will not keep. They form an excellent nutrient medium for the growth of microbes, mainly the putrefying ones. A dead animal soon rots and develops unpleasant odours, and unless one is brought up to eat decomposed meat, game, eggs and fish, it becomes " unfit for consumption."[1] Such decomposition is aided by the blow-fly, the maggots of which render meat protein soluble. Putrefaction depends upon the presence of digestible protein and moisture. If the moisture content is reduced considerably these protein foods can be kept against a rainy day. Meat and fish have been dried in the past by native races and are still being dried to make them keep. Pemmican of the Red Indians and Charque of South America and the dried fish of the Eskimo of the Mackenzie River delta are examples. And to-day this process of dehydration (really, of course, drying) is being used on a large scale to feed British and American armies overseas. The one naturally occurring high protein food (pulse) keeps very well because of its low content of water.

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[1] We eat game and cheese in a state of putrefaction ; the Eskimos eat decomposed meat ; the Chinese eat pidang—i.e. duck's eggs which have developed the odour of decay. No harm results.

The moisture of fruits and vegetables allows moulds to ruin their palatability. For many years this has been obviated by drying the fruit and there is an extensive trade in dried grapes (muscatels, raisins, sultanas and currants), dried apples and pears, dried figs, dried apricots and peaches and plums both in war-time and in peace. Some of these owe their keeping qualities in part to their high content of sugar. Dried vegetables have been used in every war within the last 100 years, but with ill results, because of the destruction of the vitamin C in the methods of drying used. In the war of 1939–45 the difficulties of drying vegetables have been overcome, their ascorbic acid value has been preserved and they can be reduced in weight to one-twentieth or less and be transported to the desert or the Arctic Circle, and when rehydrated and cooked are as good as, or possibly better than, vegetables from the home market. After the war it is likely that the trade in dried vegetables will expand. They offer too many advantages to the restaurateur to be neglected.

Dehydration of fish and meat has made such strides that it is likely that much of the fish cakes and mince we eat in restaurants in the future will be made from dehydrated foods. The problem of dehydrating joints and large pieces of meat has not been solved, if it ever will be, so that no one need suspect, as yet, that a chop or a steak, or a cut from the joint has come from a dehydrated source.

Most of us have become familiar with dried milk and dried eggs during the war 1939–45, but dried milk is said to have been made by the Tartars in the thirteenth century,[1] and it has been used in infant feeding since 1906.[2] Dried eggs, though dating from the first World War, have become a standby in the war of 1939–45, and though their taste and flavour are not equal to that of " shell " eggs, they are an exceedingly welcome addition to the war-time commissariat. They represent an enormous saving in carriage.

If and when China becomes a settled and peaceful and industrialized country it will be a chief source of dried eggs. During the second World War the eggs were produced and dried in Canada and the United States. Before this war large quantities of eggs, shelled and frozen, were imported from China into this country for use in the confectionery and margarine trades. There was considerable outcry from the poultry industry but it seemed hardly justifiable.

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[1] Appleton. (1942), *Proc. Nut. Soc.*, **1**, 114.

[2] Coutts. (1918), *Loc. Gov. Board Rep.*, **116**, 1.

Drying, then, is a means of making foods keep, though not indefinitely. The housewife uses the fat when she turns the cold roast joint over on its dish every twenty-four hours. If left moist side down the putrefactive microbes can soon render the moisture (i.e. gravy) putrid and foul smelling. But if the moist side in contact with the dish is turned uppermost, it dries and the microbes cannot thrive.

One type of drying is to produce such a concentration of sugar in the food to be preserved that microbes cannot grow. In jam-making the final sugar content is raised to over 60 per cent., in which strength of solution microbes will not grow. The honey bee uses a similar technique, though it is said also to add a little formic acid as a preservative. In the making of glacé and crystallized fruit the cell juices are replaced by stronger and stronger solutions of sugar until a strength is reached in which no microbe can grow. Sweetened condensed milk owes its keeping power partly to the condensation, partly to the concentration of sugar and partly to the bacteriological cleanliness used in its preparation.

The ***salting*** and ***smoking*** of meat, particularly pork, has been practised for more than 500 years. The meat keeps because the outside layers have such a high concentration of salt that invasion from outside is impossible. The microbes cannot live in the strength of salt solution found in the outer layers of the meat. The inside of the meat starts sterile, is protected in the early stages of pickling by its acidity and in the later stages by the salt in the outer layers. Potassium nitrate—saltpetre—also used in curing bacon and ham—is an antiseptic. Further, smoking, when used, partly owes its effect to antiseptics in the smoke and partly to the effect of still further drying the meat. (The salt will have extracted some water already.) It should be realized that the inside of a ham can easily undergo putrefactive changes if cut and exposed to the air. There is not enough salt there to plasmolyse microbes. It normally remains sound because protected by layers of concentrated salt on the outside, though infection may travel along the bone or along the big blood vessels near the bone.

Micro-organisms are the main, though not the only, cause of spoiling of foods, but some strains of the acid-producing microbes can be used to preserve food or at least to stave off putrefaction. By souring milk, particularly if alcohol is formed at the same time, the milk can be made to last longer than normal. Sauerkraut is cabbage preserved by means of acid-producing bacteria and is popular as an edible both in Germany and in the German-settled parts of the United States. Silage is cattle fodder treated in a similar way. Green Indian corn stalks and other fodder plants can be preserved throughout the winter as fodder for cattle and retain much more of the nutritive value than if first dried.

Another way of making food "keep" is to *fractionate* it, i.e. keep one fraction and throw away the rest. Butter is the fat of milk, but the caseinogen and the lactose of the milk from which the butter originated must either be used at once, or dried. It was, until recently, thrown away, or at the best used as pig food. The "Household milk" of the war of 1939–45 is the skimmed milk arising from the manufacture of butter on the North American continent. Cheese is really fractionated milk. The fat and the caseinogen, plus the calcium of the milk, are preserved, and the lactose and lactalbumin largely wasted. (Dried whey, the residue of the milk after the casein has been produced, is a valuable food.) Fractionating cereals also improves their keeping qualities but for a different reason. The oil of the cereal germ readily goes rancid in air, and the mixed proteins of wholemeal support insect life better than those of white flour. White flour does not readily develop an "off" flavour whereas wholemeal does. Whole wheat keeps better than wholemeal, and white flour nearly as well as whole wheat. This fact probably explains the determined opposition of the milling and baking industry to the production of war-time flour and bread.

Antiseptics, i.e. substances inimical to microbic life, have been in the past and are still being used to preserve food. Hops are added to the wort in beer making because they contain an antiseptic. The beer keeps better. The commonest artificial antiseptics are benzoic acid and benzoates, boric acid and sulphites. Benzoic acid is used in the fruit juice industry, boric acid in cream and sulphite in sausages and fresh fruit. In this country it is no longer legal to use benzoates and boric acid but sulphites are permitted in sausages. Before the war of 1939–45 the jam-makers of this country imported much fruit, especially black currants, from the Continent preserved with sulphite and the Camden solution used in bottling fruit is a source of sulphur dioxide. The function of the antiseptic is to poison life and there is always the possibility that it may upset human life, so the tendency is to move away from antisepsis towards asepsis in the food industry as in surgery.

If we can put up a susceptible food in a container free from microbes it will remain unchanged almost indefinitely. This is the principle behind the ***canning and bottling*** industry which has grown to such an immense size during this century. On the commercial scale it is quite impossible to prevent some microbes (bacteria or fungi) from coming into contact with the meat, fish, fruit or vegetables to be preserved before they go into the container—in fact this would be possible for meat, only in the most up-to-date operating theatre—but those which obtain entrance are killed by boiling or heating under pressure, and the vessel sealed before any more live microbes can make their entrance. With fruits and vegetables it is not necessary to raise the temperature much above the boiling point of water but with fish and meat the temperature surrounding the container has to be raised to 125° C. partly to allow the heat to penetrate to the centre and partly because the hydrogen ion concentration of meat and processed fish is favourable to the growth of putrefactive microbes while that of fruits and vegetables is not. More care to destroy all microbes is necessary with meat than with fruit and vegetables.

It should be mentioned that the greatest care has to be taken of fruit, vegetables, meat and fish before they are canned. Nothing but the best and cleanest are good enough, and the time between harvesting or slaughter and inclusion in a container has to be the shortest possible. Fruits and vegetables are canned within 24 hours of picking or pulling and often preserve more of their vitamin C than similar goods sold " fresh " on the open market. Cleanliness is at a premium in a cannery for the fewer microbes which get into the cans before sterilizing the better. That they do get in at times is shown by the " blown " cans, and the occasional occurrence of food poisoning due to canned goods. In spite of these occurrences, which are rare, the practice of canning foods has come to stay. It is very valuable in taking advantage of a glut, in transporting foods from one part of the world where they are cheaply and easily produced to another where they are produced with difficulty, if at all, and in increasing the range of food-stuffs available.

There is still a strong prejudice against canned goods though it has but little basis in dietetics. There is little if any damage done to the nutritive values of the protein, fat and carbohydrate; vitamin B_1, it is true, is probably destroyed and there is loss of vitamin C. None the less, it is true that canned fruits and vegetables often contain more vitamin C than similar fruits and vegetables, bought in the open market and cooked in the home. The objections to canning are mainly æsthetic and moral. Often canning changes the flavour of goods for the worse though there are people who prefer canned pineapples and grapefruit to fresh; and some, canned ox-tongue to fresh, and connoisseurs maintain that the longer sardines remain in their cans the better. Generally speaking, the flavour of canned goods does not approach that of fresh foods. Moreover, there is the indictment on moral grounds. The use of canned goods is held to be lazy and jeers are made about the mountains of empty cans to be found near the back doors of the working-classes. As a matter of fact, the big hotels are the greatest users of canned goods—they are so convenient and standardized in appearance. It is much easier to warm and open a can of nicely graded and dyed green peas than to shell and cook the product of a city market. Meanwhile it must be admitted that it is dietetically advantageous to be able in winter to open cans of black currants, loganberries, spinach and new potatoes in this country, or in the northern parts of the United States or Canada, where the snow is on the ground for 5 months of the year, and to have summer fruits and vegetables available in winter and early spring.

Fruit juices and, for that matter, meat juices, can be rendered sterile by filtration through Chamberland filters, i.e. unglazed porous pottery filters with holes so minute that they hold back the microbes. This method is used on an increasing scale in the United States, but it is not suitable for all fruit juices, for it holds up at the same time some of the flavour.

Partial heat sterilization, or ***pasteurization,*** is used with milk and fruit juices. Pasteurization consists in raising the temperature of the fluid to be pasteurized to a height varying for each food and keeping it there for a definite time. The length of time varies with the temperature. Thus, milk has to be held at 145° F. no less than 30 minutes—the so-called holder process—whereas if it is raised to 162° F. the time necessary falls to as little as 15 seconds. When the time is so brief the process is termed flash pasteurization. Until the war of 1939–45 the holder process was the one favoured in this country, but flash pasteurization, despite its difficulty in control, has been permitted since 1941.

The function of pasteurization is (i) to kill pathogenic germs such as those of tuberculosis, undulant fever, typhoid, etc., and (ii) to destroy most of the lactic-acid-producing microbes. This enables the milk to keep much longer—properly pasteurized milk made under laboratory conditions will keep a month, and commercially pasteurized milk as put up by a well-known dairy in Dorset will last five or six days in summer before going sour. Such milk is not sterilized—there may be heat-resisting spores in it, which will later germinate and invariably a few lactic-acid producers escape destruction. Pasteurization kills the more abundant and non-spore-forming microbes and so delays souring.[1]

Cold delays microbic activity; milk which would keep two or three days in cold weather will last hardly a day in warm; frozen meat will keep indefinitely. There are stories of hunters in the Arctic Circle coming across frozen mammoths which must have gone into cold storage æons ago, the meat of which, when thawed out, was perfectly edible. Low temperature does not destroy microbes, it merely puts them in a state of suspended animation; and in the household refrigerator they continue to live but reproduce themselves much more slowly. For example, as quoted in the *Farmers' Bulletin* No. 1705 of the U.S. Department of Agriculture (1933), a high quality raw milk which started with 31,000 microbes per cubic centimetre had increased these by four times only after 24 hours in a cool chamber at 50° F., whereas the same milk left for 1½ hours at 75° F. before its 24 hours in the cooler had 10½ times as many microbes. If the refrigerator had been working at 32° F. the increase would have been much less—probably the numbers would not have doubled in 24 hours.[2]

Cold storage then has been used in ever-increasing degree in the last 50 years. One of the difficulties encountered in preparing for feeding the people of Great Britain during the German air-raids was that the cold storage plants were naturally enough in our dock areas and so exposed to attack. Beef is imported from the Argentine "chilled," i.e. not actually frozen, whereas mutton can be imported from New Zealand to this country frozen. Frozen mutton when thawed retains its structure practically unchanged, but beef, if frozen, loses a large amount of "drip," i.e. muscle cell fluids or meat juice, when thawed. The length of time which chilling delays putrefactive decomposition by microbes in beef is not much more than that taken between the Argentine and our western ports, and that sets a limit to the distance from which beef was imported till gas storage was discovered.

Fish can be frozen at much lower temperatures than meat with advantage and after the war of 1939–45 it is probable that factory ships, supplied with machinery for rapid and low-temperature freezing, will accompany the fishing fleets. Such frozen fish if later stored at 10 degrees below freezing may remain good and untainted for eight months, and "acceptable" after four years!

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[1] The advantage to the producer, the distributor and the consumer of the delaying of the souring of milk in a highly urbanized civilization is obvious. This leaves out of account its advantage to health, for which see under milk.

[2] DAVIS. (1944), *Food Manufacture*, **19**, 423, states that laboratory pasteurized milk will keep 32 days at 45° F. and up to 63 days at 34° F.

The trouble has always been, in the fish supply in this country, that much of the fish when landed was "off," and when transported inland was by no means fresh. Refrigeration both on fishing fleets and on the railways could render the supply of fresh fish in the remotest parts of Great Britain—no part is more than 70 miles from the sea—an easy matter. The advantage of such a supply is obvious from the sections above on protein and nicotinic acid.

Gas Storage. Many foods, e.g. fruits and vegetables, are living entities and carry on a slow metabolism during storage. Others have substances in a state of complicated equilibrium which is dynamic and not static. That is, the equilibrium slowly moves, sometimes towards improvement of flavour (wines and cheeses are examples) and sometimes in the opposite direction (e.g. meat). Sometimes the foods contain oxidizable substances, usually fats and fatty acids, and the oxidation of these produces "off" flavours. It has been discovered that carbon dioxide in varying percentages will slow still further metabolism in fruits, i.e. will inhibit ripening processes; will check the development of unpleasant flavours and stop oxidation. Nitrogen could be used for the latter purpose but because carbon dioxide can be supplied in solid form cheaply it is the more convenient "gas" in which to store food. Gas storage is still in its infancy, but it has already solved the problem of carrying meat, particularly beef, from the Antipodes to Europe.

Eggs have presented peculiar problems in cold storage. The egg within its shell is by no means completely sterile and the washing of eggs seems to remove some barrier against invasion by microbes from outside. Eggs in cold storage develop a storage flavour and sometimes serve as a medium for "musty odour" producing microbes. This ruins them as food. Moreover, the firm white of the egg becomes runny and so enables it to be distinguished from a new-laid egg. A fried cold-storage egg looks nowhere near as appetising as a fried new-laid egg. Many of these troubles have been obviated by "gas" storage in combination with cold storage. The "gas" is usually carbon dioxide, though it may be nitrogen. Percentages ranging from 5 to 100 can be used according to the food to be preserved. Higher concentrations are best for eggs but lower percentages are used with meat and fruit (see below).

Gas storage has aided in the preservation in transport of foreign fruits to this country. Quite a low percentage of carbon dioxide is all that is necessary. The fruit is picked unripe and ripens on its journey to this country and in storage. The rate of ripening has to be modified according to the distance to be travelled and the time when the fruit is put upon the market. Cold delays ripening. But the fruit is a living, breathing organism and some of the products of metabolism, if not removed, speed the ripening. Carbon dioxide delays it. So in ideal conditions there should be a circulation of air around the fruit and its carbon dioxide content is best kept at 5 per cent. Gas storage of apples has proved of great value and it may in future be possible to pick bananas much more nearly ripe and so preserve some of the qualities of a banana picked ripe from the tree.

Gas storage, too, has solved the problem of preventing the development of "off" flavours in dehydrated foods, particularly those which have to pass through, or be stored in, tropical climates. Originally with dried milk coming from New Zealand a vacuum was used to prevent the development of "off" flavours, which probably are due to the fats becoming rancid. Dehydrated meat, fish and eggs retain their qualities for much longer if put up in metal containers filled with nitrogen or carbon dioxide. Probably the same method could be used to prevent oxidation of the essential oils of roast coffee beans, tea and cocoa nibs.

Advantages and Disadvantages of Food Processing. Apart from the apathy usual in the public about anything that matters, there are two attitudes of mind adopted towards modern food manufacture: out-and-out condemnation and out-and-out approval. The instinct of one brought up in the country on home-killed and cured bacon, on home-grown vegetables and fruit, on milk, butter, cheese, eggs and poultry from the home farm, and meat killed by the village butcher, is to raise his hands in horror at modern methods of food production, transport, and processing. It must be confessed that in the past—and indeed the present—the sophistication of some food, e.g. the tinting of canned peas with aniline dyes, the bleaching of flour by oxides of nitrogen, chlorine dioxide and similar reagents, the faking of wines and beers and jams, the use of synthetic flavourings (e.g. benzaldehyde for almonds) and the dyeing of kippers, leaves a nasty flavour in the mouth, metaphorically and actually. Nor can the cynical or ignorant attitude of commercial firms in the past, and even during the war of 1939–45, be defended .Malt is expensive, glucose made by the action of sulphuric acid on potato starch is cheap. It was therefore used in the wort from which beer was made, and poisoned beer addicts within a large radius from the brewery thirty years or so ago because the sulphuric acid was contaminated with arsenic.

Public analysts during the second World War have been kept busy analysing catchpenny egg, milk, lemon and other fruit "substitutes," "guaranteed to contain all the food values" of the foods for which they were supposed to be substitutes, showing their claims to be unfounded and reporting them to the Health Authorities.

The other attitude is to welcome the change because of the much greater variety of foods which can be supplied to our highly urbanized civilization. But the modern methods of processing foods demand scientific control—chemical, biochemical and bacteriological control—at all stages. Until recently the scientist has been but grudgingly admitted into industry and then more often as a subordinate than as a director. In the food industry the need for competent biologists, as well as chemists, is beginning to be recognized. The Food Group of the Society of Chemical Industry has done and is doing much to demonstrate the need for biological control in food manufacture, and a journal of the name *Food Manufacture* which reached its majority in 1946 is a welcome evidence of the advance that control is making.[1] There are progressive firms in which the biochemist holds a dominating position.

It must be recognized that the processing of food is inevitable in an urbanized civilization. If the standard of living is to be raised the country must be industrialized, and industrialization (though it may not be so in the distant future) entails urbanization. The town folk must be catered for with food preserved in some degree or other. Consequently it is our task to see that it is conducted as well as may be, and we have to admit, if we look at the matter impartially, that it has given great advantages. For example, with milk it has not only raised the keeping quality, but it has raised the standard of milk production. The milk distributors are as much in favour of clean milk as the most fanatical medical officer of health. The same is true of the canning of meat, fruit and vegetables. The best only are good enough. And the time will come when manufacturers will cease to put up a concoction of sugar, citric or tartaric acid, a coal tar dye, and synthetic flavouring and call it a fruit juice.

The endeavour to produce a really white flour, so decried by food reformers, has not been without its benefits. Apart from the odd coins, trouser buttons and nuts from the combine harvester which have to be removed from the grain before it goes through the rollers in the flour mill, there is a not-inconsiderable quantity of other seeds, some of them even poisonous, which have to be removed, and are removed, by ingenious machinery. Presumably our Norman ancestors ate them in their bread, even in their white bread. Processing, on the whole, makes for cleanliness—even bacteriological cleanliness—and quality.

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[1] None the less, *Sugar in the Air*, a novel by E. C. Large, is not a wild exaggeration.

What are the drawbacks of processing? There can be little or none in the proteins, fats and carbohydrates of the foods. It is difficult to believe that the mineral elements are in any way lost.[1] It is only in the realm of the vitamins that damage occurs. Generally speaking, there is little loss of vitamins A and D in processing, though it has been reported that canned herrings have less of both than the fresh product. Vitamin C certainly is decreased in the canning of fruit and vegetables, though, as said above, there is often more vitamin C in these than in the same food bought on the open market and cooked at home. Probably nicotinic acid and riboflavine withstand processing, but vitamin B_1, thiamine, disappears either by leaching out, destruction by sulphite or by high temperature in processes such as dehydration and canning. As, however, goods so canned or dehydrated rarely contain much vitamin B_1, this loss is not serious. More serious is it with the cereals. Normally the production of a white flour from wheat reduces the B_1 from about 1 I.U. per gramme to $\frac{1}{4}$, though it should be possible in future by including the scutellum with the endosperms or by breeding special wheats to raise that amount. It is said that some of the processes of producing breakfast cereals destroy the vitamin B_1—e.g. the " puffing " of wheat and rice—and it is difficult to see how some breakfast cereals can retain any of that vitamin, though so far as we know actual biological experiments are lacking.[2] Processing, then, is inevitable; it has its advantages and disadvantages; the former have raised the standard of food here and elsewhere, the latter can, with ordinary intelligence, be obviated.

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[1] But see the section on cereals for the welcome loss of mineral elements.

[2] 100 grammes puffed, shredded and flaked wheat have 5, 67 and 13 I.U. vitamin B_1.

CHAPTER VIII

THE COOKING OF FOODS [1]

Many foods in their natural state are quite unfit for human consumption, e.g. cereals, pulses, cassava, and have to be "processed" before eating. A home "process" is that of cooking and it has been practised from time immemorial. It is possible that cooking was first applied to cereals, though there is plenty of evidence that prehistoric man had learnt the value of cooking his principle food, viz. meat.

The object of cooking food is twofold: (i) *Æsthetic*—to improve its appearance and to develop in it new flavours. Even animals prefer their food cooked. (ii) *Hygienic*—to sterilize it, to render it more digestible and to evoke, during its consumption, greater flow of gastric juice.

Cooking meat, fish and milk, foods with a considerable amount of protein or fermentable carbohydrate, puts off the period when they will "go bad," by destroying the microbes which normally bring that about. (A wise cook brings the contents of her stock-pot to the boil once every twenty-four hours.) Further, cooking destroys many dangerous parasites which may lurk in ill-inspected meat.[2] It also destroys the toxins manufactured by *bacillus botulinus* but not, unfortunately, those made by the salmonella group of microbes.

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[1] See on this subject B. Lowe, *Experimental Cookery* (London, Chapman & Hall, 1932); McCance and Shipp, "The Chemistry of Flesh Foods and their Losses on Cooking," *Med. Res. Council Rep.*, No. 187, 1933; and McCance, Widdowson, and Shackleton, *Med. Res. Council Rep.*, No. 213, 1936.

[2] Animal parasites found in meat are not capable of withstanding a temperature of 70° C. (158° F.) All ordinary forms of cooking will therefore render meat free from this source of infection. An outbreak of trichiniasis in the Birmingham area of this country in 1941 was due (i) to insufficient inspection of the pork used, and (ii) to the habit of the people in this part of the world to eating some of the sausage meat *raw*.

Cooking certainly increases the digestibility of vegetable foods and is said to improve that of meat, possibly by destroying the antiferments in it and by loosening the fibres. Even though the coagulation of the proteins of meat may render them less digestible *in vitro*, the increased attractiveness of well-cooked food may render it indirectly more capable of digestion by calling forth a more profuse flow of psychical gastric juice.

The application of heat in some form or another being the essential part of all ordinary processes of cooking, it is important to have clear ideas as to the ***effect of heat upon the different chemical constituents of food.***

The effect of heat on the ***proteins*** of the food is to coagulate them. It would be a complete mistake, however, to suppose that a boiling temperature is essential for bringing about this change, for coagulable proteins, both animal and vegetable, begin to coagulate if their temperature is raised to 60° C. (140° F.). Above that the protein contracts or shrinks in most animal foods, though eggs and fish roes are exceptions. This shrinkage is accompanied by a small decrease in digestibility.

Of the ***carbohydrates*** of the food, starch is the most affected by heat. Dry heat converts starch into a soluble form, and ultimately into dextrin. This change occurs to a limited extent in the crust of bread, and also in the making of toast and biscuits. Moist heat causes the starch grains to swell, and ultimately to rupture their envelopes, and the starch is then said to be *gelatinized*. That this change also takes place considerably below the boiling-point of water is known to the laundress or the cook. If boiling water be poured on to cold " blended " flour, starch or cereal, it gelatinizes, although the temperature of the mixture cannot ever be as high as 100° C. (212° F.). Oat starch is said to gelatinize at 85° C. (185° F.), and potato starch at so low a temperature as 65° C. (149° F.).

Here again one sees that in the case of some starchy foods the change which it is the object of cooking to effect can be brought about at a comparatively low temperature.

The effects of heat upon *cane sugar* in acid solution, as in stewed fruits and jams, is hydrolysis. The cane sugar is " inverted " to glucose and fructose. The partial conversion of sugar into caramel is one of the means by which flavour is developed in food by cooking.

The ***fats*** of food are not so much affected by heat as the proteins and carbohydrates. At high temperatures, however, as when one of the dry methods of cooking is employed, some at least of the fat may perhaps undergo a partial decomposition, with the liberation of free fatty acid and acrolein. The latter irritates the mucous membrane. Fat which has been heated and allowed to cool again is often found to have become more granular than it was before. This change is probably due to the driving off of water, and it tends to render the fat more brittle, and consequently more digestible. The change is well exhibited in the case of dripping, and also in fried bacon.

With these preliminary considerations we may proceed to the study of the effects of cooking upon animal and vegetable foods respectively.

Cooking of Meat

The ideal to be aimed at in cooking meat is to decompose its red colouring matter (hæmoglobin), so as to remove its raw appearance, and to do this without overcoagulating the proteins of the meat or removing from it its flavouring ingredients (extractives).

We may glance very briefly at the means by which this ideal is to be attained in the ordinary methods of cooking.

Boiling. It is unfortunate that the term " boiling " should be applied at all to any method of cooking meat, for it implies that the subjection of the meat to the temperature of boiling water (212° F.) is an essential of the process. But this, for the reasons indicated above, is a mistake. The red colouring matter of the meat is decomposed and rendered brown at a temperature considerably below that of boiling water, and by raising things to the boiling-point one runs the risk of hardening the meat by overcoagulation of its proteins.

That the boiling-point is not essential for the complete coagulation of the proteins can be most easily proved in the case of an egg. If two eggs are taken, and one kept in water at a temperature of 80° C. (175° F.) for ten or fifteen minutes, and the other for an equal length of time in boiling water, it will be found at the end of the experiment that the contents of both are solid throughout, but that in the case of the former they consist of a tender jelly, whereas in the boiled egg they are dense and almost leathery. Several so-called egg-boilers, indeed, have been introduced which work upon the principle of cooking the egg at a temperature considerably below the boiling-point of water.

Now, what is true of an egg holds good also for meat, and accordingly the first principle to be observed in the " boiling " of meat is to see that the temperature of the water does not rise much above that which is required for the coagulation of proteins. It is only by giving heed to this that one can achieve the first result desired—the abolition of the raw colour of the meat with avoidance of overhardening.

The second object to be aimed at, that of retaining all the flavouring constituents of the meat, also demands some care. The flavour of meat is due to its extractives and salts, and both of these are readily dissolved by water. If the water in which the meat has been cooked is to be consumed in the form of soup, the partial removal of some of these flavouring ingredients is not of much importance; but if the meat alone is to be eaten, precautions must be taken to prevent their being dissolved out.

One way of doing this is to use as *small a quantity* of water as possible; for the larger the proportion of water to meat, the greater will be the amount of soluble substances removed. The quantity of water, therefore, should be just sufficient to cover the meat, and no more.

A belief popular in cookery books is that the exposure of meat for a few minutes to the temperature of boiling water creates a pellicle of coagulated protein on the outside impermeable to the soluble constituents within. Such a procedure, with a later lowering of the temperature, has been advocated in order (i) to conserve these constituents, (ii) to continue the coagulation of the proteins. An investigation of the premises of this theory shows them to have no foundation in fact.[1]

A summary of the effects of cooking meat in water, taken from McCance and Shipp's work, is here given:

When fully cooked, beef is found to lose the same amount of weight, water and salts, whether cooking is begun in hot or cold water.

The application of heat over 60° C. (140° F.) to flesh foods causes a shrinkage of their proteins and the expression of juice. When the meat is heated in water there is in addition a minor loss of salts due to diffusion into the surrounding water.

The rate of shrinkage is accelerated by raising the temperature, but the final result is but little different whether cooking is brought about by long exposure to a lower temperature or short exposure to a higher temperature, though it is slightly increased if the higher temperature is used.

Shrinkage is less rapid and less in amount in absolutely fresh killed than in "conditioned" meat. This is probably not due to the formation of lactic acid in rigor mortis.

The more rapidly the shrinkage occurs the less important becomes the loss due to diffusion into the surrounding water. The smaller the pieces cooked the greater is the loss due to diffusion. With small portions of meat the salt losses are greater when the meat is boiled than when steamed, but with larger portions it makes little difference whether they are cooked in water or in steam.

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[1] McCance and Shipp. 1933, *Med. Res. Council Report*, No. 187. These authors point out that earlier research work has given little support to the pellicle theory since it was propounded by Liebig. None the less, it has flourished even in "scientific" articles upon cookery.

In general if boiling is used to cook meat it makes little difference to the final losses whether the meat is boiled quickly, slowly, or if the temperature is lowered soon after the beginning of cooking, *so long as the meat is cooked to the same degree.* Cooking at a higher temperature achieves the result aimed at more quickly, but it is easier to over-shoot the mark at high temperatures than at lower but adequate temperatures.

Roasting. In the process of roasting, the heat is conveyed to the meat by direct radiation, instead of through the medium of water. The effect of roasting upon meat is similar to that of boiling ; shrinkage occurs, causing an expression of the juices of the meat. These, however, are evaporated to dryness on the surface of the joint, and are therefore not lost as they are in boiling, so that roasting, baking and grilling are conservative methods of cooking. The greater heat at the surface of the joint brings about a change in the protein expressed and coagulated thereon with the production of more sapid substances, and it is to these and the greater concentration of the salts that the outside cuts owe their characteristic flavour. The loss of weight in roasting is nearly all due to evaporation, but a loss of salts can be increased by reducing evaporation, as, for instance, by basting.

The puffiness of a well-cooked chop or steak by grill is to be explained by the greater shrinkage of the outside and more " overdone " layers as compared with those inside.

Baking acts in precisely the same way as roasting, the heat in that case being applied all round the meat at once, instead of only to one side at a time. Connoisseurs prefer roast meat to baked meats.

Stewing is in many respects the ideal method of cooking meat. If properly performed, it coagulates without overhardening the proteins, while, owing to the fact that the juice is eaten along with the meat, none of the flavouring ingredients is lost. At the same time, the prolonged action of heat and moisture converts most of the connective tissue into gelatin, so that the fibres readily fall apart and the meat becomes very tender. Here, again, the secret of success consists in avoiding too high temperatures. It is not sufficient to place the pan near the edge of the hotplate, and allow it to " simmer " instead of " boil." The use of a thermometer will show that the temperature of " simmering " and " boiling " water is really the same, i.e. 212° F., the only difference being that in the former case the heat is reaching the water more rapidly and more of it is wasted. In proper stewing the temperature should not be allowed to rise above 82° C. (180° F.).

COOKING OF FISH

The flavouring ingredients of fish are even more easily dissolved out by water than those of meat; and as fish has less flavour to start with, any loss is the more carefully to be avoided. For this reason boiling, unless very carefully performed on the lines above laid down, is not a suitable method of cooking fish. The experiments of McCance and Shipp show that boiling may result in a loss of 40 per cent. of the salts. It might be expected that cooking by steam would be preferable, and this is certainly true of small pieces of fish.

Frying is a method of cooking specially applicable to some forms of fish, and demands a special word of description, especially as the process is so often misunderstood.

The essence of frying consists in the sudden exposure of the object to be cooked to a very high temperature. This leads to such rapid evaporation from the surface that the loss of salts and nitrogenous matter is reduced to a minimum. Such method of cooking naturally adds considerably to the fat content of the final product. For example, steamed whiting has 0·9 per cent. of fat; whiting with batter and crumbs has 10·3 (McCance and Shipp).

In order to attain this very high temperature, some form of fat must be used as a medium. Olive oil or good cottonseed-oil are best. The oil should be heated in a deep pan almost to its boiling-point (the actual temperature is about 180° to 200° C.—356° to 392° F.); and when this temperature has been reached the object to be fried should be lowered gently into the pan, and left for two or three minutes. The bubbling which ensues is due to the conversion of the moisture on the surface of the object into steam. When this has ceased the cooking will be complete, and the object should be lifted out and the excess of oil allowed to drain off.

It will be observed that this process differs entirely from the so-called "frying" usually practised in this country, in which the fat employed is regarded merely as a means of preventing the object from adhering to the surface of the shallow pan, in which a sort of roasting is really accomplished.

COOKING OF VEGETABLE FOODS

In the cooking of vegetable foods the objects to be achieved are different from those which one seeks to accomplish in the case of animal foods. Cell-wall substances and raw starch are almost incapable of digestion by man, and hence the softening and rupture of the cellulose framework of a vegetable food and the gelatinization of its starch grains are the chief ends which it is the purpose of cooking to bring about.

Cell-wall substances can be softened, and, indeed, partly converted into sugar, by the action of acids, aided by heat. Nature uses ferments. In its unripe state a pear or other fruit is hard and "woody" from the presence of a cell-wall framework. In process of ripening the acids in the fruit, aided by the heat of the sun and ferments, effect a softening of this framework, with partial or complete solution of the cellulose fibres, the product being the sweet and soft ripe fruit.

This method is sometimes unconsciously imitated by man. The process of preparing *ensilage* is an example of it. Here, under the influence of fermentative bacteria, acids are produced in grass which, by the aid of moisture and heat, act upon the cellulose, and effect a partial conversion of it into sugar. In Germany a very similar process is employed in the conversion of cabbages into *Sauerkraut*.

The preparation known as *sowans* is an example of the operation of a similar agency on the cellulose of oatmeal. Ordinary porridge, also, when allowed to stand for some time, becomes a soil for the growth of acid-forming bacteria, and the products of the growth of these bring about some degree of softening of the cellulose in the particles of oatmeal. For this reason porridge is often found to be more digestible when stale than when perfectly fresh.

Another way of overcoming the cellulose obstacle, which may in a sense be regarded as a process of cooking, is by ***milling*** or ***grinding***. This breaks up the cellulose framework, and allows the digestive juices to penetrate into the nutritive ingredients which it encloses.

More commonly, however, one finds the same object accomplished by the combined action of heat and moisture. When exposed to moist heat starch grains, as we have seen, swell up, their envelopes rupture, and they run together to form a paste or starch jelly. As this jelly expands it presses upon and ultimately ruptures the framework of cellulose in which the grains are enclosed, and in this way the two chief objects aimed at are achieved. The degree to which this occurs is very well shown in the accompaning diagrams (Figs. 8, 9, and 10), which illustrate the action of moisture and heat upon the structure of a piece of potato.

It will be evident from these considerations that cooking is of immense importance in facilitating the digestion of vegetable foods,

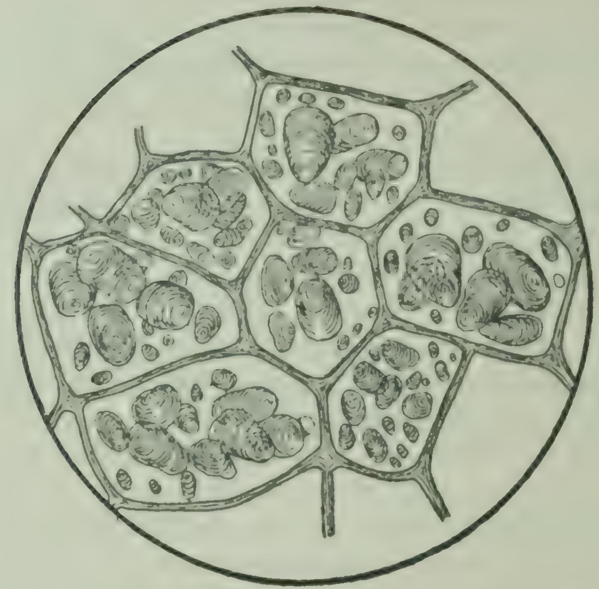

FIG. 8.—CELLS OF A RAW POTATO, WITH UNRUPTURED STARCH GRAINS AND CELLULOSE FRAMEWORK.

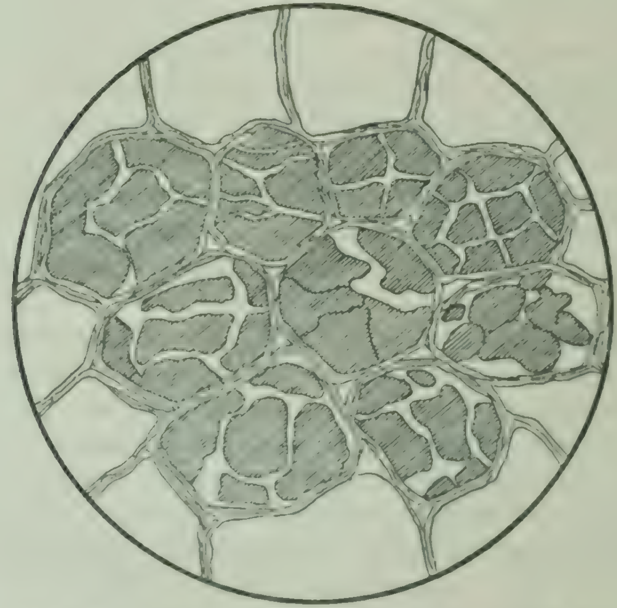

FIG. 9.—CELLS OF A PARTIALLY COOKED POTATO, THE STARCH GRAINS RUPTURED.

and the larger the proportion of cellulose present, the more essential does thorough cooking become.

Heat has an effect on the ***proteins*** of vegetables precisely similar to that which it exerts on the same constituents of animal food; that is to say, they become coagulated. Now, the coagulation of proteins is accompanied by shrinkage rather than by swelling, and for this reason, if the cellulose framework encloses protein only, it does not become ruptured; and one can therefore readily understand that if a vegetable food contained protein alone its digestibility would be affected by cooking in a precisely similar way to that of animal food; in other words, it might be rendered less rather than more digestible by the process. The explanation of this apparent paradox is that vegetable foods containing much protein also contain much starch (e.g. the pulses) and that the starch in gelatinizing ruptures the cell membranes. Green and root vegetables contain but very little protein.

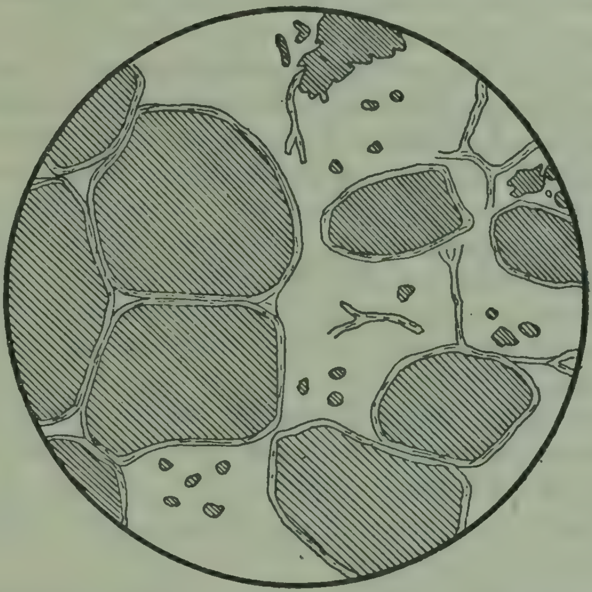

FIG. 10.—CELLS OF A THOROUGHLY BOILED POTATO; CELLULOSE FRAMEWORK BROKEN DOWN.

LOSSES IN COOKING

No matter how carefully cooking is performed, a certain amount of loss of the soluble constituents of the food during the process is inevitable. In the case of meat, it has been found by Johnston that—

	In Boiling.	In Baking.	In Roasting.
4 lb. of beef lose in weight .	1 lb.	1 lb. 3 oz.	1 lb. 5 oz.
,, mutton lose in weight	14 oz.	1 lb. 4 oz.	1 lb. 6 oz.

By far the larger part of this loss, however, is due to water. König showed that the percentage of water in lean beef falls from 71 to 57 per cent. when boiled and to 55 per cent. when grilled. Veal cutlets lose water to a similar degree. Investigations for the U.S. Department of Agriculture showed that the loss other than that of water is confined almost entirely to extractives and salts. Very little protein is lost and though fat drips out this can be recovered except when grilling over an open fire.

As far as their soluble constituents are concerned, vegetable foods behave similarly, the loss of salts especially being often very considerable. The loss, however, is more marked in the potassium and magnesium salts than in the iron and calcium, which are hardly affected.[1]

As regards water, the behaviour of the two classes of foods on cooking is entirely different, for vegetable foods become richer in water when boiled, instead of losing it.

Water Content (per cent.) of Foods before and after Cooking

Vegetable Foods.[2]			Animal Foods.[2]		
	Raw.	Boiled.		Raw.	Boiled.
Macaroni .	10·4	72·2	Beef . . .	70·3	46·2
Oatmeal. .	8·9	89·1	Ham . . .	55·8	48·6
Potatoes .	75·8	80·5	Mutton . .	[67·1]	45·5
Pulses . .	8·7	70·5	Haddock .	81·3	75·1 (steamed)
Semolina .	12·2	71·7 (as pudding)	Plaice . .	80·8	78·0 (steamed)

One may, therefore, lay it down as a general proposition that animal foods become less watery as the result of cooking, while vegetable foods, on the contrary, become more watery.

This is another explanation of the different effect which cooking exerts on the digestibility of the two classes of foods. The concentration which meat undergoes when cooked is unfavourable to digestion, while the dilution of the vegetable foods after cooking makes less demand on the digestive juices. This, too, is one reason why meat which has been cooked more than once is rather difficult of digestion. Not only are its proteins apt to be over-coagulated, but the relative proportion of fat is increased at the same time, and both of these facts militate against rapid and easy digestion.

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[1] McCance, Widdowson, and Shackleton. (1936). *Med. Res. Council Rep.*, No. 213.

[2] McCance and Widdowson. (1942). *Chemical Composition of Foods, Med. Res. Counc. Special Rep.* 235.

On the other hand, the increase of bulk which vegetable foods undergo as the consequence of taking up water in the course of cooking is apt to throw a strain on the *mechanical*, as opposed to the purely chemical, functions of the digestive organs. The bearings of this fact upon the practice of vegetarianism will be discussed in a later chapter.

SLOW COOKING

Since food is a bad conductor, heat only penetrates into it very slowly. Wolffhügel and Hüppe,[1] for instance, found that the temperature of the interior of a piece of meat weighing 9 lb. after 4 hours' boiling was only 88° C., or 12° below the boiling-point of water. The interior temperature of a roast varied from 70 to 95° C., according to size. Similar observations have been made by Sir Henry Thompson.[2] He found that the temperature close to the bone of a leg of mutton which had been boiled or roasted for some hours was never above 85° C. (186° F.)

Hence it is that, if heat is applied to a piece of meat too rapidly, one simply wastes fuel and runs the risk of overcooking the outer layers. It is far better to allow a moderate amount of heat to act on the meat for several hours, and the longer the time allowed, the lower will be the temperature required, always assuming that it is kept above the coagulation-point of proteins, i.e. above 70° C. (158° F.). This is the practice in high-class restaurants. Various special forms of apparatus have been invented with the view of economizing fuel, and allowing of the prolonged action of a moderate degree of heat, some of which are certainly not as well known as they deserve to be.

The simplest of these are constructed on the principle of an ordinary water-bath, and consist of a double pan, the outer being filled with water which is kept at, or near to, the boiling-point, while the article to be cooked is placed in the inner vessel. The heat only penetrates slowly to the latter, and never reaches the boiling-point, while any risk of burning is also prevented. The French "bain-marie" is constructed on this plan.

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[1] Quoted in U.S. Dept. of Agriculture, Bull. 21.

[2] *Food and Feeding*, p. 97. His results have been confirmed by others (see B. LOWE, *op. cit.*).

The "Welbank Boilerette" is a modification of the "bain-marie," in which the steam from the outer pan is prevented from escaping and reaches a temperature above 212° F., so that the food in the inner vessel can be actually boiled.

Somewhat different from these is the Fireless cooker or Haybox. There are many forms of this apparatus. The commercial type consists of one or two compartments lined with polished sheet metal and heavily lagged on the outside with asbestos, kapok or other insulating material, and enclosed in a wooden box, with a thick door also well heat-insulated. Aluminium saucepans with detachable handles fit the space within the compartments very snugly. When food is to be cooked, it is brought to the boil in one of the saucepans, boiled for 5, 10 or more minutes according to the size of the food, the lid is clamped down and the saucepans transferred at once to the fireless cooker, shut in, and allowed to cook by its own heat for any time up to 24 hours. The apparatus acts on the principle of preventing loss of heat, and just as it prevents any heat getting out, so it can with equal efficiency prevent any from getting in. It may, therefore, be used as a refrigerator, for keeping ices, etc., unmelted, quite as well as a cooker. It saves a great deal of time, trouble, and fuel, and is very useful to travellers and campers-out, or in any circumstances in which one wants hot food constantly ready. The only objection to its use is that it destroys vitamin C, but so long as that fact is recognized and an assured source of vitamin C taken in addition no harm is done.

A home-made form can be manufactured from an old-fashioned hatbox stuffed tight with hay except for a central space for the saucepan, and a non-conducting lid improvized from a kapok or flock cushion. Such devices come into prominence with each major war we have experienced in Great Britain, at any rate in the advice given by Schools of Domestic Science to the public, but it would be interesting to know how many were constructed and continued in use. Of the commercial form one of us (V. H. M.) can speak with great satisfaction after an experience with it extending over thirty years.

A little reflection will show that, in the use of an ordinary oven, a great waste of fuel is inevitable, for the metal of which the oven is constructed is an admirable conductor, and allows heat to escape almost as fast as it gets in. In order to prevent this and the waste of fuel which results from it, all that is necessary is to have the oven covered with some non-conducting material. The heat supplied by the fuel will then be unable to escape from the oven, and will all be utilized to cook the food, instead of being to a large extent dissipated into the surrounding atmosphere. All electric and most gas stoves and two anthracite stoves, the Aga and the Esse, are now constructed on this plan, but the usual English range remains much as it was when this book was first written.

It is interesting to note that the advantages of slow cooking are well known to some savage tribes, and in this respect the civilized cook has something to learn from them. This is the method of cooking practised by the Kanakas of the Friendly Islands, as described by the late F. T. Bullen :[1]

" A hole is scooped in the earth, in which a fire is made (of wood), and kept burning until a fair-sized heap of glowing charcoal remains. Pebbles are then thrown in until the charcoal is covered. Whatever is to be cooked is enveloped in leaves, placed upon the pebbles, and more leaves heaped upon it. The earth is then thrown back into the cavity and well stamped down. A long time is, of course, needed for the viands to get cooked through ; but so subtle is the mode that overdoing anything is almost an impossibility. A couple of days may pass from the time of ' putting down ' the joint, yet when it is dug up it will be smoking hot, retaining all its juices, tender as jelly, but, withal, as full of flavour as it is possible for cooked meat to be. No matter how large the joint is or how tough the meat, this gentle suasion will render it succulent and tasty ; and no form of civilized cookery can in the least compare with it."

No better illustration of the advantages of *slow* cooking could well be found.

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[1] *The Cruise of the " Cachalot."* (1898), Smith, Elder & Co., London, 273.

CHAPTER IX

HYGIENE OF FOOD

This subject demands a whole book to itself and a slight sketch only can be attempted here. We think that even such a sketch should be valuable to the domestic science students who use this book.

The subject has a two-fold aspect: national and personal or domestic. The country as a whole and the local authorities are responsible for much of the hygiene of food production; for its final preparation the home, the institution, the canteens and the restaurants are concerned. There is the provision of a safe water supply, still extremely incomplete in country districts, and of satisfactory sewage disposal, often primitive in many quarters. There is the collection and treatment of household waste and the regulation of dumps. These all affect food hygiene. Further, the authorities have the task of inspecting abattoirs, food factories, dairies, bakeries and so on, which directly concern food. Naturally such an intimate thing as food is influenced by every activity of man.

As so much of our food is prepared for us before it reaches the home and as this centralization is increasing and will continue to increase, the national control of food hygiene becomes ever more and more important. It is or should be the Government's business directly, or indirectly through the local authorities, to deal with the water supply, with milk and dairy products, with meat, poultry and eggs. In war-time a Ministry of Food is essential, and it is no less essential in times of peace.

National Control of Food Hygiene. It is a fact in food hygiene, that plain dirt does not matter half so much as contamination with pathogenic microbes. One of the most dangerous outbreaks of typhoid fever in this country originated from a dairy farm near Bournemouth producing high-grade milk. Contamination of milk with cow-dung, unpleasant as the fact may be, is nowhere near so dangerous as contamination of that milk by typhoid microbes from the hands of a farm worker or by tubercle bacilli from the udder of the cow.

There is no doubt that the Croydon water supply was singularly free from what people call "dirt," but a chance contamination by a typhoid carrier produced a deadly epidemic. None the less the presumption is that cleanliness of water supplies, dairies, bakeries, abattoirs, markets and so on will make for bacteriological cleanliness of the food produced there as well, though Stenhouse Williams in his work on clean milk production showed that first-grade milk could be produced in a cowshed which would unhesitatingly be condemned to-day.

In water supply, Great Britain has led the world, but none the less the two serious outbreaks of typhoid during the decades 1920–30 and 1930–40, those of Malton and Croydon, have been due to contamination of the water supply. In the example of Croydon, as said above, it was by means of a carrier. There are people who, having recovered from typhoid to all clinical observation, nevertheless carry typhoid microbes around in their large intestines, possibly for the rest of their lives. They void these every day, and carelessness in personal hygiene results in the dispersal of these microbes into food. The classical example of a typhoid carrier was "typhoid Mary" of the United States, but there have been numerous examples in this country, where typhoid is, none the less, a very rare disease. The case of the Wrexham pork pies *circa* 1910 presents an interesting phenomenon. There was a typical carrier in the employ of the cookshop. The microbes from his large intestine infected the gelatine solution used for pouring into the pork pies before baking, but because the pies were then cooked, the microbes were killed and there was no outbreak of typhoid. None the less there was a severe epidemic of food poisoning, traceable to the pork pies, because the typhoid bacilli had produced toxins in the gelatine.

Typhoid carriers must never be allowed to handle food, and that means that they must not work in abattoirs, bakeries, dairies, fisheries, market gardens, watercress beds and the like. It is one of the duties of the medical authorities, working with agricultural and Home Office authorities, to see that typhoid carriers are not employed in the food industries or around water supplies. Nor should they work in towns and cities. As these people have to work on the land, so as not to be a danger to society, it is difficult to see what, apart from afforestation, corn and stock raising they can do. Doubtless carriers of other diseases exist, for example scarlet fever, and these diseases may be transmitted by food. In the United States the theory is held that "infantile" paralysis is transmitted by fæces, as in infective hepatitis.

Milk and cream may be infected with the organisms of bovine tuberculosis, undulant fever, scarlet fever and typhoid, and so carry it to human beings. There are still a considerable number of deaths from bovine tuberculosis in this country (say 2000 per year) and widespread tuberculosis of glands and joints in the young due to the same disease. These could be obviated if Government had the courage to make the pasteurization of milk compulsory. The other dairy foods, butter and cheese, do not appear to transmit diseases much, though cheese in the United States has sometimes been shown to be the cause of an outbreak of food poisoning. The duck egg may transmit an enteritis if not properly cooked and it might be worth the while of the relevant authorities to inspect duck farms for such disease.[1]

Meat can transmit diseases in two ways: (1) it may become infected with microbes of the salmonella group. This, once thought to happen in the abattoirs through carelessness, is now considered to occur in the butcher's shop or home and is due to transmission by rats and mice. It has been thought that these microbes produce toxins indestructible by the heat of cooking and it is known that they can grow in the human alimentary tract and produce vomiting and diarrhœa, often of a dangerous nature. But as there is no *direct* evidence for these heat-stable toxins, inspection of meat in the abattoirs will only reduce the risk of food poisoning via meat, but it cannot prevent it because the chief source of infection is in the butcher's shop and the home.[2] (2) It may be infected with parasites, which, if the meat is not "properly cooked," can be transmitted to man. Proper inspection of the carcasses of meat in the abattoirs can eliminate this trouble, so can cooking. It will be remembered that an outbreak of trichiniasis in the neighbourhood of Birmingham in 1941 was due to sausage made from pork inadequately inspected and eaten either raw or lightly cooked.

Shellfish and watercress beds have been known to spread typhoid. Oyster and mussel beds form in the estuaries of our rivers and as a careless civilization wastes its sewage by the convenient method of running it into the rivers, it is not astonishing that in the past typhoid has been transmitted via the oyster and mussel. Such shellfish beds need the most careful inspection. Watercress has to-day an undeserved reputation for spreading typhoid. Whenever an important person gets typhoid (e.g. the late Arnold Bennett) it is rumoured that he got it by eating watercress. We are not aware of any cases in this country within the last twenty years being attributable to watercress from commercial watercress beds.

A reform long overdue in this country is the screening of abattoirs, meat and fish markets, bakeries and food manufactories and lavatories from flies. The house-fly has been incriminated in the United States for the spread of typhoid, and is strongly suspected in this country of disseminating summer diarrhœa. In the States it is considered as a possible vector of poliomyelitis and in North Africa (El Alamein) of infective hepatitis and bacillary dysentery. On any account, knowing the haunts of flies, it is time that they should go. Refuse dumps should not be tolerated.

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[1] *Lancet*, (1945), **1**, 314.

[2] Personal communication by Dr. C. E. Dukes.

Finally, the food manufactories, where such edibles as brawn, pork pies, potted meat, sausages, etc., are made, need close inspection. Food waste in such places encourages cockroaches, crickets, mice and rats—all potential vectors of disease. For reasons given above a known typhoid carrier should be not permitted to work in such places, and for reasons which will be obvious there should be adequate lavatory accommodation, with washhand basins and an abundance of hand towels. Operatives should be encouraged to wash after attending to bodily needs. The same applies to canteens and restaurants. People with sore hands, faces and throats should not be allowed to prepare food. A recent example is of a woman cutting sandwiches when in the early stage of scarlet fever. Some of the eaters of these sandwiches had a subsequent gastro-enteritis from the toxins produced by the scarlet-fever microbes, some later developed scarlet fever.

Of course, it is not only the trades and the health authorities who need educating, it is the public also. One of us (V. H. M.) has seen a string bag of shellfish, out of their shells, lying on the filthy platform of a London Station and while this edition was under revision a wholesaler, under the noses of the two authors, dumped a load of cabbages destined for a local greengrocer in the gutter in front of the shop. Typhoid and paratyphoid are spread by carelessness in personal hygiene.

Food Hygiene in the Home. By the time food reaches the home it may or may not have picked up pathogenic organisms or developed toxins. It might be thought that there is little that can be done in the way of food hygiene. That is not true. There is always avoidable wastage due to moulds, putrefaction of meat, soups and fish, and the depredations of cockroaches, mice and rats. In fact there is often a vicious circle set up. The failure to use crusts of bread, or to clear out the crumbs from bread bins, leads to mouldiness of the whole loaves and so on in geometrical progression. The same is true of animal life encouraged in kitchens by the lazy scattering of food. The more food scattered, the more is unwanted animal life encouraged and the more food wasted because of its being fouled by such animals. One of us (V. H. M.) has suffered from a serious invasion by crickets encouraged by the almost inevitable scattering of crumbs in a children's dining-room—an invasion, be it said, finally quelled after it had reached *titanic* dimensions by the use of a well-known insect powder.

Much spoiling of food is due to flies, more particularly, of course, to the bluebottle fly. And if the British would only learn from America to screen its houses from flies in summer, great would be the saving of food. In institutions it is the common custom to prepare food and even put it out long before it is to be consumed. We have observed this in preparatory, public and industrial schools; in university colleges and in hospitals. In fact we have begun to think that it is universal. Apart from the desiccation of the food entailed it gives the flies their chance to contaminate the food.[1]

Of course the biggest reform necessary in the British kitchen is the installation of a refrigerator. This would prevent much of the souring of the milk and the putrefaction of the meat, fish and soup stock in summer, besides preventing access of flies, cockroaches, mice and rats. If milk were sold satisfactorily pasteurized—or frozen—brought to the home in refrigerated vans and put straight into a large refrigerator it would be unnecessary to have more than one delivery a week. In Canada already they have but two deliveries a week in some cities. Of course the home refrigerator working at a temperature below 50° F. merely delays microbic action and cannot be relied upon to keep food indefinitely. Moreover, the refrigerator must be kept scrupulously clean, otherwise it may spoil more food than it preserves.

Until that millennial time when there is a working, though cheap, refrigerator in every home the ordinary housewife must use her intelligence, rather than a piece of machinery, to keep food sweet.

For example, the meat when delivered is presumably infected only on its outer surfaces, the interior being kept aseptic by its raised hydrogen ion concentration. Washing these over with a little vinegar will certainly delay the development of putrefactive microbes. It can then be hung up in the larder, all surfaces being exposed to the air, till it is cooked. It is unwise to leave it on a plate. The drip from the meat will collect under the joint and make a good medium for the growth of anærobic microbes which produce foul-smelling compounds. If the cooking of the joint is to be postponed some time it is as well to sterilize (for the time) the outer surfaces of the joint by putting it in a hot oven for a quarter to half an hour. This will not prevent the growth of microbes if they have tracked any distance along the bone or the blood vessels, but it will delay putrefaction from microbes settled on the surface. It is possible that pouring boiling water over the joint may have the same effect, but the moisture later on will encourage bacterial activity. Drying the outside surfaces by heat will discourage it.

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[1] In one school it was the sparrows which benefited. This school had had epidemics of intestinal trouble among the alumni and had sought the source of the trouble in vain. No one questioned the invasion of the dining-hall by flocks of sparrows.

In another school the sugar was put into the tea-urns with the tea after the midday meal and the lids left off. The flies in summer took full advantage of this until boiling water was poured on them later in the afternoon in the making of the "tea." The attitude of the staff was that the inmates should consider themselves lucky to be getting the food and drink provided. We wish that these were isolated instances.

It is as well to bring a stew to the boil—or, working upon the adage that a stew boiled is a stew spoiled, to 70° C. (158° F.) as quickly as possible. If it is warmed slowly there is a long period of time during which the microbes are encouraged to multiply rapidly. Also if the stew is not to be used the same day it is as well to put it away in the pan it was cooked in with the lid clamped down. It is thus less likely to grow microbes than if transferred to another container, unless that container is bacteriologically clean—a rare state of affairs in an ordinary kitchen. It is advisable to bring any " left over " to the boil before storing it in the larder, though a refrigerator will make this practically unnecessary.

If this had been practised in a heat wave in 1938 an unfortunate incident would not have occurred. A man who had taken his family to the seaside returned to Hammersmith and ate the remains of a shepherd's pie made by his wife on the previous Saturday. (He had been told to throw it away.) The pie, quite unexpectedly had grown the botulinus microbe, and the man died. Reheating that pie would have destroyed both the microbes and the toxins they had made.

Other foods than meat can play unexpected pranks on being kept in the warm for a time. A sample of oatmeal—Scottish oatmeal from a good Midlothian firm—on being put to soak overnight in the boiler room, so that the phytases could split up the phytates, developed an odour of rancid butter each time the experiment was tried. Doubtless that sample was infected with butyric-acid-producing microbes, for it never happened if the oatmeal was sterilized first (and the phytases—as well as the microbes—unfortunately destroyed).

The most important part of kitchen hygiene is to have plenty of running hot water and soap. Probably only a million out of the eight million kitchens in this country possess both such necessities. Soap is a moderately efficient antiseptic, though it will not kill every microbe. It is perhaps best to rinse plates, dishes, etc., in hot water after they have been washed with soap and water, and leave them to dry spontaneously, rather than to dry them with a cloth. The "tea cloths" can easily pass on milk souring and other microbes to the containers. It is a good practice in hot weather to steam out any milk can used for unpasteurized milk. In the experience of one of us (V. H. M.) this enabled milk to remain sweet which otherwise went sour in less than 12 hours.

Finally, it is unwise to adopt an Antipodean plan of letting the household dogs lick the kitchen china clean. This has often resulted in the transmission of a parasite that produces a serious disease of the liver. And it must not be forgotten that in countries such as China where human excreta are used as manure, there is the possibility of infection with ascaris, a round worm inhabiting the gut, if raw salad vegetables are eaten. Investigation among Oriental students in American universities showed that one-third of them were so infected. If the composting of garden refuse with human excreta becomes at all widespread in this country, it is possible that the same trouble will beset us here. Very careful washing of the salads will be essential.

In the above, the possibility of the transmission of disease by food has been emphasized—some may say too much emphasized. It is certainly true that the emphasizing of the dirtiness of much milk sold in the past has prejudiced people—medical officers of health among them—against milk as a food. The campaign for clean milk has worked in the direction of decreasing the consumption of milk. There is decidedly a danger in giving the public a fear of microbes, but it has to be faced. It is good that the public should understand the ubiquity, the services and the disservices of microbes, and how to take advantage of the one and obviate the other. Much of the control of the disservices is in the hands of public authorities and this control needs backing by an educated public opinion. In the home the control of them is valuable mainly in preventing the waste of food, a crime at most times, but particularly so in the present and near future. It may reasonably be said, however, that the wonder is how little disease is traceable to contamination of food with parasites or microbes, but it has to be admitted that when such enemies get under our guard the results (witness the Croydon typhoid epidemic and the outbreak of trichiniasis in the Birmingham area) are sufficiently devastating.

CHAPTER X

THE DIGESTION, ABSORPTION AND METABOLISM OF FOODS IN HEALTH

Very few constituents of very few foods are in a fit chemical state for use by the body. The simple hexose sugars, the inorganic salts, and the vitamins, possibly also the fats, may pass straight into the blood or lymph stream unchanged and without ill effect. Proteins, the disaccharides, dextrins, starch cannot so pass. Moreover, as they occur in foods they are often " tied up " in cellulose (or rather plant cell wall) envelopes, and these envelopes have to be cooked and macerated and triturated to allow the escape of the contents. Complex chemical substances like proteins, starches, and dextrins have to be hydrolysed to simple soluble diffusible crystalloid compounds and these, if useless as such to the body (e.g. the disaccharides), have still further to be hydrolysed. To carry out these triturations, macerations, and hydrolyses the body has a series of organs and glands secreting a variety of ferments; these processes of trituration, maceration, and hydrolysis are termed digestion.

Digestion

In the Mouth.

The mouth stage of digestion is mainly a mechanical one and its object largely protective. The food is ground by the teeth to small particles and at the same time thoroughly mixed with saliva; hard substances are broken up, softened, neutralized, diluted and covered with a wrapping of mucus so that on their passage through the alimentary tract they may easily be digested without undue difficulty and without abrading or otherwise damaging the soft walls of that tract. Thorough chewing of food is important. Without it, food may damage the alimentary tract and cannot be adequately digested. To bolt food, in the manner in which one posts letters, interferes gravely with proper disintegration of it; and many cases of dyspepsia are kept up, if not actually produced, by imperfections of the teeth or dentures.

In addition to the neutralizing, moistening, and lubricating effect of saliva there is a chemical influence as well. Cooked starch, of whatever origin, is digested by the ptyalin of the saliva via dextrins to maltose. Some starches—e.g. those of rice and maize—are more readily acted upon by the saliva than others, such as potato starch. Raw starch is hardly affected at all.

As most animals have ptyalin in their saliva and as man presumably passed through the stage when he did not live on cooked plant foods, this ptyalin must be looked upon as a fortunate accident for him, or perhaps as " intelligent anticipation." But since it is there, one had best make the best use of its power of digesting cooked starches.

Porous foods, such as rusks, into which the saliva can easily penetrate, are more easily attacked than dense and compact masses, such as new bread. Moist substances, too, offer less resistance than those which are dry. In fact the amount of saliva secreted varies, among other things, with the dryness of the food. Dried powdered meat, Pavlov showed, when given to a dog evokes a thin watery and abundant saliva, but when given in its original form only a scanty but highly mucous secretion. Doubtless something similar happens in man.

The amount of saliva varies too, naturally and markedly, with the tastiness of the food and with appetite. If a person has a strong conditioned reflex for food, even if that food be distasteful to the majority of people—e.g. caviare to the general and durians to the occidental—that food will evoke a great flow of saliva. Dehydration of the body shows its first effect in decreased salivation. A person who is thirsty cannot produce saliva, a thing worth remembering when feeding a dehydrated person. Acidity of food, certainly, and a mild astringency, seemingly, increase salivation, but intense astringency such as that of an unripe persimmon " dries the mouth up." Vinegar, malt liquors, wines, and tea inhibit the digestion of cooked starch by saliva *in vitro*, but it is possible that, because these substances provoke a salivation *in vivo*, their inhibiting effect is overcome.

Another important use of saliva which must not be forgotten is that of washing the mouth clean from food particles which would otherwise remain between the teeth and undergo decomposition. (Witness the foul condition of the mouth when salivation is suppressed in fever.) So important is this hygiene of the mouth that many dental surgeons advise that a meal should end with raw crisp fruit, which stimulates a flow of saliva besides having in itself cleansing properties in view of its detergent action.

In the Stomach.

Observations of the results of complete removal of the stomach in man have shown that its co-operation cannot be regarded as essential to the complete digestion and absorption of an ordinary mixed diet provided the latter is presented to the intestine in a suitable mechanical form. None the less it has several functions to perform :

1. To act as a reservoir.
2. To bring the swallowed food to a semi-fluid form.
3. To sterilize the food—at least in part.
4. To regulate its temperature.
5. To effect a small degree of digestion of proteins.
6. To produce (*a*) an "intrinsic" factor which, reacting with an "extrinsic" factor of the food, manufactures a hormone for maturing the red cells of the bone marrow, and (*b*) the neurotropic hormone, which normally makes for the well-being of the spinal cord.

We shall briefly consider each of these functions separately.

1. By ***acting as a reservoir*** the stomach enables us to take our food in considerable quantities at a time ; i.e. it renders *meals* possible. The practical convenience of this needs no demonstration, but some points connected with the question of meals may again be raised.

First it may be asked, ***At what intervals should meals be taken?*** Is it better to take several small meals or to consume one's daily supply of food at one or two sittings ? The problem will be discussed again later from the point of view of physiological efficiency, but here we may treat it from the point of view of physical capacity. The "one-meal-a-day man" is at a twofold disadvantage: (1) he is apt to overburden the mechanical powers of his stomach by the mere weight of food introduced into it at one time ; (2) some of the food so introduced may be wasted owing to the digestive, absorptive, and assimilative powers of the alimentary tract and body-tissues being unable to keep pace with the flood of material which reaches them all at once.

(1) The capacity of the human stomach is very variable, both in different individuals and in the same individual at different periods of life. On the average it may be estimated as from 2 to 4 pints and in the case of solids at about 2 lb. If it be remembered that the total amount of solid food required daily is about 3 lb., it is evident that if the whole of this were eaten at one meal the stomach would be overtasked and a dilatation of that organ incurred. If the stomach is unhealthy it will be unable to tolerate

food at the rate of three meals a day (let alone one) but might be able to carry on if meals were given "little and often."

(2) There is evidence to show that more food is wasted when it is taken all at once than when it is spread over a considerable time. The waste occurs in all the constituents of food and is partly due to defective digestion leading to defective absorption and to increased intestinal putrefaction. The results of Jacobean and Georgian orgies as related by the diarists are sufficient evidence of this, and there is experimental evidence pointing in the same direction. Moreover, as has been related elsewhere, a large amount of protein taken at one meal results in a much greater wastage of heat (the specific dynamic action of protein, q.v.) than if that amount of protein is spread more evenly over the day. It follows that the protein ration should not only be adequate in amount but that it should be divided between three or four meals a day in order that the best use may be made of it. The old custom at schools and hospitals of giving only bread and butter for breakfast is evil and has been largely abandoned. The growing child and the sick patient need adequate supplies of amino-acids for growth and repair, and enough should be given at the first meal of the day to make up the deficiency caused by the fast which occurs during the night.

The principle of so dividing the meals is one of great value whenever the stomach is unhealthy and will be discussed later.

The hours of meals have varied greatly even in the same country at different periods of history and in different classes of society, and must depend largely upon convenience and upon habits as regards work, etc. If possible, dinner, the principal meal of the day, should be taken after work is over, or at midday, provided that a period of rest can be observed after it. The custom in schools of playing games shortly after a midday meal is a bad one which, fortunately, in the more progressive preparatory and public schools is being superseded by a period of rest, lying down, of half an hour's duration.

2. The second function of the stomach is partially ***to digest the food and bring it to a semi-fluid form.*** This is done partly by the action of the ferment pepsin in the gastric juice and partly by the mechanical movements of the stomach walls. We may therefore glance for a moment at—

The Secretion of Gastric Juice. Until the beginning of this century it was supposed that the secretion of gastric juice was brought about by mechanical stimulation of the mucous membrane of the stomach by the particles of swallowed food. Pavlov [1] showed this to be a mistake in a series of most ingenious experiments upon dogs and his discoveries have been confirmed for man by Richet, Carlson, and others. He showed that the chief factors concerned are (1) psychological, and (2) chemical, and that mechanical action plays quite a secondary part, if any at all.

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[1] Pavlov. *The Work of the Digestive Glands.* London, 1902.

The psychological factor is bound up with the sensations of appetite and hunger. These two sensations are so intimately related that a clear understanding of the terms is essential. The two experiences are fundamentally different. Appetite is related to previous sensations of taste and smell of food. It is, or rather accompanies, a conditioned reflex. At one time in a person's life the taste and smell of a food (e.g. an olive) may awake nothing but nausea, but at another and more sophisticated age, intense appetite. Psychological elements are therefore important components in appetite. Appetite may be divorced from hunger, as for instance at the end of a large meal when there is still an appetite for the savoury and the dessert. It is probable that many a well-to-do person leading an ordered life never feels hunger and that his needs as regards food are satisfied by the call to eat through appetite. On the other hand hunger will cause people to eat things for which they normally have no appetite, and, indeed, when hunger is acute, things actually revolting.

Hunger has a painful quality while appetite is pleasurable. Hunger undoubtedly normally stimulates appetite. Foods are more pleasant to eat when one is hungry, but as said above hunger can be divorced from appetite. Its physical basis is undoubtedly the cramp-like contractions into which the stomach goes when one is hungry.[1] These are the result usually of deficiency of nutritional substances in the blood. The blood of a hungry animal sends the stomach of another animal into hunger contractions. Such depletion may account for hunger in man, for some diabetic patients, especially children, complain of great hunger whenever the blood sugar falls below 90 milligrammes per 100 millilitres, though others may not although the blood sugar may fall as low as 40 milligrammes per 100 millilitre. The action of insulin in lowering the blood sugar is sometimes used in an endeavour to increase hunger and so stimulate appetite.

Appetite is the psychological factor which causes a flow of gastric juice. In dogs, as well as in man, a liking for a food that is eaten evokes a greater flow of gastric juice than if a food be eaten for which there is distaste. Pleasant service and pleasant surroundings also improve appetite and therefore evoke a greater gastric response as Hawk and Rehfuss have shown in work upon American medical students.

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[1] CANNON. (1929), *Bodily Changes in Pain, Hunger, Fear, and Rage.* Appleton & Co., New York.

Hence the dietitian emphasizes the importance, especially when feeding the sick, of agreeable surroundings, of clean napery and dainty china, and of good cooking in promoting good digestion, and will make a point of consulting the likes and dislikes of patients. Hence too the prevalence of the habit of the glass of sherry before dinner, or the cocktail, and the savoury items usually classed on the menu as hors d'œuvres.

The second factor concerned in producing gastric secretion is a chemical one. Pavlov was the first to discover that meat and watery extracts of meat produce a secretion of gastric juice even when the "appetite" juice is obviated by feeding the animal through a fistula when it is asleep. He also showed that partially digested foods have the same effect. Later research has shown that some part or other of these foods acting on the mucous membrane of the pyloric end of the stomach releases into the blood-stream a hormone, which travelling round the circulatory system comes back to the mucous membrane of the stomach and stimulates the glands to secretion. It is claimed that glucose, alcohol, lactic acid, sodium bicarbonate, saliva, or meat will liberate this hormone. Still more potent than meat are extract of meat, albumoses, and peptones. The hormone may be histamine.

The normal course of secretion is (i) that there is an appetite juice secreted as the result of a gustatory conditioned reflex. This juice is constant in composition, containing hydrochloric acid and pepsin. (ii) There is a second prolonged secretion of the glands continuing long after the reflex flow is over as the result of the setting free from the pyloric mucous membrane of some hormone into the blood-stream. This second [1] flow will therefore vary with the nature and state of digestion of the food in the stomach. The combined results of all these factors will doubtless account for Pavlov's observation that each food calls forth a response specific to that food.

There are also, in addition to chemical excitants to the flow of gastric juice, chemical depressants. Fat is a notorious example, and was first discovered to be so by Pavlov. Later, cane sugar has been added to the list by the work mentioned above of Hawk, Rehfuss and colleagues. This not altogether unexpected result suggests perhaps the disadvantage of sweet things before a meal.[2] Iced water and *strong* alcoholic drinks are also depressants. Sodium bicarbonate given before a meal stops the secretion of gastric juice, but given with or after a meal increases it. The bearing of these facts on the dietetic treatment of hyper- and hypo-acidity and of peptic ulcers is obvious.

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[1] According to Ivy there is a still further chemical influence arising from the products of digestion in the small intestine.

[2] E.g. Fruit at breakfast, "Fruchtsuppe" as in Germany and iced melon in this country in hot weather.

Acidity of the Gastric Contents. The total amount of hydrochloric acid present in the stomach depends upon the quantity of gastric juice secreted, which may be as much as 700 c.c. after a large meal. Of the total amount of acid secreted after a meal only a small part remains in the free form ; the larger part is in a state of combination with protein. The first part of the hydrochloric acid secreted is neutralized by the bases present in the food (e.g. carbonates) and after these have been neutralized the rest is free to unite with the proteins. There is always some free hydrochloric acid over and above that which combines with the bases and protein of the food. The average figure for free hydrochloric acid in pure gastric juice is 0·4 to 0·5 per cent. Pure juice is difficult to obtain and it is usual to use the figure obtained after a fractional test meal, or after giving histamine or alcohol.

Bennett and Ryle examined the gastric juice of 100 healthy students at Guy's Hospital, using the gruel test meal, and found that 84 per cent. of the curves for acidity fell between what are called the normal limits of 0·040 to 0·180 grammes of hydrochloric acid (11 to 50 c.c. of N/10 Hydrochloric acid), with a mean of 0·118 (32 c.c.), at the end of 1¼ hours after the meal ; 7 per cent. rose a little above 0·180 (50 c.c.) at that time but began to decrease later like the 84 per cent. which were within normal limits ; 5 per cent. exceeded 0·180 grammes at the end of 1 hour and continued to climb (the " climbing curves ") ; and 4 per cent. of the cases showed complete achlorhydria.[1] The causes of these individual differences are not clear and none of the students complained of gastric symptoms.

The amount of acid begins to decrease after 1¼ or 1½ hours and this decrease is believed by Bolton to be due to the regurgitation of alkaline fluid from the duodenum as the proportion of total chloride to free hydrochloric acid increases about this time except in those patients who have a " climbing curve."

The gastric juice then is markedly acid ($p_H = 1{\cdot}6$ to $1{\cdot}8$) and we have to consider the relations of this acidity to (1) the digestion of starch in the stomach ; (2) morbid gastric sensations.

Digestion of Starch in the Stomach. There is no doubt that ptyalin is rapidly destroyed by free acid and that its action on starch ceases at about $p_H = 4$. The rate of digestion of starch by ptyalin depends on the concentration of hydrogen ions in the medium. It is at its maximum at $p_H = 6{\cdot}9$ or just on the acid side of neutrality. So soon as the combination of protein with acid in the stomach fails to keep the hydrogen ion concentration at or beyond this figure the ptyalin digestion of starch falls off. When starchy foods undergoing salivary digestion are thoroughly mixed with gastric juice that digestion ceases.

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[1] *Guy's Hospital Reports.* (1921), 71, 286.

It follows then that starchy foods will not go on digesting for long in the stomach, at any rate if they are mixed with the earlier portions of the meal ; in the later portions of the meal carbohydrate digestion can continue much longer. Observations with X-rays have shown that the food last swallowed is received into the centre of the mass already present in the stomach, and does not for some time come into contact with the gastric juice. The central portions therefore can retain an alkaline to mildly acid reaction for a considerable period during which ptyalin can go on digesting the cooked starch. This justifies the conventional arrangement of a dinner in which the starchy course (pudding) comes after the protein course (meat).

Relation of the Acidity of the Stomach Contents to Morbid Gastric Sensations. In health, digestion proceeds quite unconsciously and without the production of any sensation at all. In morbid conditions of the stomach, however, digestion may be accompanied by sensations of pain, and these seem to arise in at least two ways : (1) from disorder of the motor functions of the stomach ; (2) from abnormal conditions of the mucous membrane.

The former of these we shall consider later. The latter seem to be of two sorts : (*a*) where the mucous membrane is unhealthy and is unduly sensitive to the *total acidity* of the contents ; (*b*) where *free* acid alone produces pain. The former of these conditions seems to be present where actual lesions of the mucous membrane exist —e.g. in acute and chronic gastritis, ulcer, and in carcinoma ; the latter, if it ever occurs, is apparently more often of the nature of a neurosis—a hyperæsthesia of the nerves of the mucous membrane, though it is possible that in extreme degrees of such hyperæsthesia pain may be produced even by combined acid. Where the total acidity causes pain the condition is likely to be aggravated by foods rich in protein, such as meat, for these, as we have seen, call forth an abundance of juice, and therefore of acid. If, on the other hand, free acidity alone excites the sensation, such foods are likely to be beneficial, for they delay the period at which free acid appears, and also lessen its amount. In accordance with this explanation it will usually be found that patients who are suffering from ulceration of the stomach complain of pain after meat, but can digest milk with comfort; for milk not only neutralizes much acid by means of its proteins, but in itself calls out the secretion of a weak and scanty gastric juice. On the other hand, one usually finds that patients with functional dyspepsia and hyperæsthesia of the stomach suffer less from meat than from foods which, being poor in proteins, allow of the early appearance of uncombined hydrochloric acid. These considerations are of importance in helping one to select a suitable dietary for dyspeptics.

One other function of the hydrochloric acid is to render some metallic radicles of salts more available. Thus calcium phosphate may become calcium chloride and passing down into the duodenum may be absorbed as such. Hypochlorhydria may account for a difficulty some people show in absorbing sufficient calcium and iron from normal diet.

Movements of the Stomach. In studying the movements of the stomach, one must distinguish quite sharply between the cardiac and the pyloric end of the organ. The two ends are distinct, both anatomically and functionally. The cardiac end secretes both pepsin and hydrochloric acid, the pyloric end pepsin and the hæmatopoietic substance. The former has but feeble motor power; the movements of the latter are more powerful.

Possibly as the result of Cannon's masterly work on gastric peristalsis in the cat, the amount of movement in the stomach of man has been exaggerated. Radiograms purporting to be normal have indicated an amount of movement that we now know to be abnormal. Barclay [1] shows a picture of a normal stomach emptying its contents into the duodenal cap in which there is little or no peristalsis and another where the peristaltic waves are of the mildest, and contrasts these with one where there is excessive peristalsis. The latter more closely resembles the normal appearance in the cat. Thus both active and quiet peristalsis may occur in health, and we do not know yet what determines the one or the other.

The stomach is a U-shaped cavity with one limb (the pyloric) shorter than the other. The cardiac end remains quiescent but, towards the pyloric end, peristaltic waves may mix the food up, but this mixture is not an essential mechanism, though it is brought into action if the food contains any large unmasticated lumps. The main propelling force must be the intragastric pressure due to the tonus of the muscular walls of the stomach. From time to time the pylorus opens and allows food to enter the duodenum, and according to Barclay this opening is probably controlled by a reflex mechanism actuated from the region of the ileo-cæcal sphincter and is not due to peristalsis of the stomach or to change in the acidity of the gastric contents.

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[1] *Amer. Journ. Roentgenology.* (1938), 40, 330.

The length of time which elapses between the swallowing of food and the first opening of the pylorus is variable, depending chiefly upon the consistence of the food and the temperature of the stomach contents. Fluids, unless they contain much solid matter in suspension, begin to escape almost immediately—water, indeed, whilst it is still being swallowed.

Any excess of fluid taken with a solid meal is probably also passed on almost at once, and so cannot seriously dilute the gastric juice. Solid food can only escape after it has been brought to a fluid or semi-fluid consistency, and this must obviously depend to a large extent upon its physical characters and density.

An opaque meal of porridge and bismuth oxynitrate can be seen escaping from the stomach within ten minutes of being eaten, and estimation of the blood sugar shows that it has risen ten minutes after glucose has been taken by mouth and twenty minutes after a porridge meal.

The larger part of a meal, however, probably does not pass out of the stomach till most of it has been completely digested, and half an hour after that has taken place the stomach may be regarded as empty.

Rate of Digestion of Different Foods. The response of the normal human stomach to various foods was first investigated by Beaumont in his classical experiments on Alexis St. Martin, and Penzoldt made careful observations in 1893. From 1912 onward till the subject's death from cancer of the stomach Carlson produced a number of communications concerning digestion in the stomach of Vlček, a Czech, with a surgically-made gastric fistula. The method of removing small amounts of food at frequent intervals after a meal by means of the Rehfuss tube has also given much information. There were among the students investigated by Hawk, Relfuss and others two types of stomachs—the slow and the quick. The slow did not complete its emptying under 3½ hours, whereas the quicker type of stomach was empty in 2½ hours. The time which the slow and quick acting stomachs take to empty and the highest total acidity observed are shown in the table on p. 235. The results destroy some popular beliefs. Thus 100 grammes of beef and lamb were both digested in about the same time, 3 hours and 25 minutes for the slow, and 2 hours and 35 minutes for the more quickly emptying stomachs, whereas chicken and ham take ten to twenty minutes longer. Further, roast beef was digested in the same time whether it was underdone (American " rare "), medium, EVACUATION TIME AND HIGHEST TOTAL ACIDITY FOR VARIOUS ARTICLES OF DIET [1]

Articles of Diet (100-gramme portions unless otherwise stated).	Number of Observations.	Evacuation Time (Hours and Minutes). Type of Stomach.			Highest Total Acidity (average) (cc. N/10 Alkali to Neutralize 100 c.c. Juice).	Grammes of Hydrochloric Acid.
		Rapid Emptying.	Slow Emptying.	Average.		
Beef and beef products . . .	25	2.35	3.25	3.00	120·0	0·40
Lamb and lamb products . . .	14	2.30	3.20	3.00	135·0	0·492
Veal :						
(*a*) Market . .	7	—	—	2.50	140·0	0·51
(*b*) "Bob" . .	7	—	—	3.20	110·0	0·40
Pork and pork products . . .	31	2.45	3.40	3.15	120·0	0·44
Chicken . . .	20	2.45	3.45	3.15	125·0	0·455
Turkey	2	3.00	3.45	3.30	140·0	0·51
Guinea Hen . .	2	—	4.00	4.00	110·0	0·40
Fish	75	—	—	2.50	130·0	0·475
Milk :						
Cow's, 75 c.c. .	3	—	—	1.15	45·0	0·164
400 c.c. .	50	—	—	2.30	100·0	0·365
Mother's, 150 c.c.	5	—	—	1.40	60·0	0·210
225 c.c.	2	—	—	2.25	90·0	0·328
Gelatin	5	—	—	2.00	70·0	0·255
Egg and egg combinations . .	90	2.15	3.15	2.40	80·0	0·240
Vegetables prepared in different ways . . .	124	2.00	2.30	2.50	75·0	0·275
Fruits	68	1.35	2.20	2.00	90·0	0·328
Bread and cereals	75	—	—	2.40	80·0	0·240
Cakes	29	—	—	3.00	90·0	0·328
Pies	29	—	—	2.30	90·0	0·328
Puddings . . .	23	—	—	2.20	90·0	0·328
Sugars and candies	28	—	—	2.05	70·0	0·255
Ice-cream . . .	7	—	—	3.15	105·0	0·384
Ices	4	—	—	2.35	65·0	0·238
Nuts :						
(*a*) 25 grammes	18	—	—	3.00	100·0	0·365
(*b*) 500 grammes	4	—	—	4.00		

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[1] HAWK, REHFUSS and BERGHEIM. (1926), *Am. J. Med. Science*, **171**, **359**.

or well done. Bacon took nearly one hour longer to digest than beef. Two eggs, cooked in various ways, were digested ten minutes quicker than 100 grammes of beef. Raw eggs left the stomach a little quicker, but if they were boiled hard an extra ten minutes was taken. Vegetables as a whole left the stomach in two hours but cabbage and asparagus were got rid of in one and a half hours. Raw lettuce took only one hour, but the addition of sugar, vinegar, and oil, delayed the emptying a little.

The observations on the digestion of milk are most interesting and were carried out on one man who had the power of regurgitating small samples of milk at regular intervals. The curds from raw whole milk were like rubber and as big as a man's thumb, but those obtained when the milk had been boiled for five minutes were soft and no bigger than a pea. The curds obtained from pasteurized milk were intermediate in size between those of the raw and boiled milk. Those obtained from skimmed milk were much larger and very hard. The character of the curd was directly affected by the fat content and the addition of extra cream made the curds considerably smaller, though the stomach took longer to empty.

The addition of 2½ grammes of sodium bicarbonate to 500 c.c. of raw whole milk caused the formation of smaller soft curds, though the change was not so marked as that produced by boiling.

The observations on pies [1] showed that the pie crust was evacuated in 2 hours 52 minutes, while the fruit portion was got rid of in 26 minutes less time. The addition of 100 grammes of sugar delayed evacuation, but small amounts (10 grammes) had no effect. The figures for the secretion of acid are also surprising. The highest figure of 140 c.c. is given by veal and turkey, whereas beef and pork with 120 c.c. are below both chicken and fish. Eggs and bread produce relatively little, only 80 c.c. The figures for milk are rather difficult to evaluate, as 400 c.c., which is a large amount to drink, caused an acidity of 100 c.c., while 75 c.c. (2½ oz.) produced 45 c.c. of acid. It seems probable that some of the old observations are correct, i.e. that mashed potatoes are more rapidly disposed of than boiled potatoes, and that old potatoes are better tolerated than new potatoes. Firm bread and biscuits are found to be more digestible than new bread, but there is little difference between crust, crumb and toast and between new and stale bread, provided all are equally well chewed. These observations have not yet been repeated since the introduction of the fractional method of testing the stomach.

3. Antiseptic Action of the Gastric Juice. Another function which the stomach serves is that of partially sterilizing the food by the antiseptic action of the hydrochloric acid of the gastric juice. This action, however, is not a powerful one, and some organisms such as those which form acids, seem to escape it altogether, and there is reason to believe that the same is true of some, at least, of the commoner pathogenic organisms, notably the tubercle bacillus.

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[1] The American pie is what we should term a turnover.

The sterilizing power of the stomach must vary greatly according to the period of digestion and the nature of the food. It probably reaches its maximum towards the later periods of digestion, when hydrochloric acid is present in the free state, whilst it is much less, or even absent altogether, in the earlier stages, when all the hydrochloric acid is in a combined form. Food rich in protein, by fixing the hydrochloric acid, must greatly lessen the germicidal power of the gastric juice. The stomach has little control over the growth of organisms in the intestine. The small intestine remains free from putrefactive organisms even if there is achlorhydria in the stomach or, indeed, when the stomach has been completely removed.

4. The Temperature of Foods and Drinks. One of the minor functions of the stomach is that of regulating the temperature of the food. It stands in this matter as a protector of the intestine, which appears to be more injuriously affected by extremes of temperature than the stomach itself.

The ideal temperature for food is probably that of the body itself. Cold food is difficult to digest, for it does not excite the stomach sufficiently, nor does it possess the stimulating properties of a hot meal. It has been said that there is a special craving for alcoholic stimulants on the part of those who are unable to get hot meals, but this is not borne out by observation on Arctic explorers.

Extremes of temperature in foods should be avoided as tending to produce local injury to the stomach; from 45° to 130° F. are probably the limits of safety. Many people, however, are able to take ices and iced drinks with impunity for many years.

Drinks at a temperature of 50° C. (122° F.) make one feel warmer and at a temperature of 7° C. (45° F.) cooler. Wunderlich found that hot punch at 122° F. raised the temperature of the body by ·03° to 0·1° C. for a period of thirty to sixty minutes, while half a litre of water at the same degree of heat caused an acceleration of the pulse nearly 20 beats per minute very shortly after it had been swallowed.

On the other hand, three tumblerfuls of water at a temperature of 45° F. produced a lowering of the axillary temperature from 98·4° F. to 97·7° F., while the pulse-rate fell from 70 to 61 per minute.[1]

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[1] Most of the effects detailed must be due to reflex vasodilatation or constriction of the skin bloodvessels.

The *local effects of extremes of temperature* in the stomach are very much the same whether the extreme be one of heat or of cold. In each case there is a danger of exciting gastric catarrh. Very hot foods seem to be specially dangerous in stomach-bleedings, e.g. ulcer; and there are some who say that the special liability of cooks to suffer from gastric ulcer is to be attributed to their constantly tasting very hot foods. On the other hand, very warm fluids may relieve pain in the stomach by abolishing pyloric spasm.

The temperature most suited for drinks intended to ***quench thirst*** is one of from 50° to 70° F. Ices are supposed to cause dyspepsia, cardialgia, and even acute dilatation of the stomach, although small quantities of ice undoubtedly tend to allay gastric irritability. Possibly the English fear of the dietetic use of ice and ices is exaggerated.

5. The Digestion of Proteins. The digestion of protein is initiated in the stomach. Ultimately protein has to be disintegrated into its component amino-acids before it is of use to the body. The pepsin of the gastric juice does not carry digestion any great distance. Its function is to attack the huge molecules of protein and resolve them into smaller fragments which have, however, still a large molecular weight. Apparently the acid of the gastric juice first combines with the protein and then the pepsin begins its work. The first product is the metaprotein known as acid albumin or syntonin. The next product is primary albumose (or proteose) and the next, secondary albumose. These are in a descending scale of molecular magnitude. Peptones are also found in peptic digests. These form a group of still lower-sized molecules and are feebly diffusible through animal membranes. Most peptic digests consist of a mixture of all these partially digested proteins together with a small amount of free amino-acids. How far such digestion proceeds in the stomach depends upon the length of time the protein food remains there and upon the amount of pepsin secreted. There is some evidence that pepsin attacks not the peptide linkages in protein but some other type of linkage, and there are a few proteins which are better digested if gastric digestion precedes pancreatic digestion.

On the whole it must be admitted that gastric digestion of protein is not indispensable and its importance can easily be over-estimated, as in the fallacious rationale underlying the Hay diet.[1] As said before, digestion of protein is initiated in the stomach, but it is only carried to the full extent of complete chemical disintegration into amino-acids in the small intestine under the influence of trypsin and erepsin.

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[1] See p. 674.

Milk undergoes clotting in the stomach and according to most observers this is due to a special ferment, rennin which turns the caseinogen of milk into casein and the latter combining with calcium gives a clot of the insoluble calcium caseinate. Some people regard this clot formation as the result of an early stage of digestion of the caseinogen by the pepsin. The bearing on dietetics is that milk clots in the stomach, that skimmed milk forms a very tough clot, raw whole milk a tough clot, pasteurized milk and boiled milk softer clots, and dried milk when reconstituted a friable clot. The digestibility varies with the size and nature of the clot.

6. The Production of the Hæmatinic Principle. Apparently another ferment (Castle's intrinsic factor) is secreted into the stomach, but from the pyloric end, which, acting on an "extrinsic substance" in foods, e.g. beef, marmite, etc., produces from them a hormone which is essential in causing the red blood corpuscles of the red marrow to mature and be liberated into the blood. According to Castle the extrinsic factor, though apparently related to the B complex of vitamins, is neither thiamine, riboflavine, nicotinic acid, xanthopterin, pyridoxine, inositol, folic acid[1] nor pantothenic acid. Patients with pernicious anæmia do not secrete this "intrinsic factor." This function of the stomach is, possibly, more important than all the others enumerated above. It is also believed that the stomach secretes a **neurotropic hormone** which protects the nervous system from the degeneration which occurs in the disease called subacute combined sclerosis of the cord. This hormone has, however, not been separated from the hæmatinic hormone.

Absorptive Power of the Stomach. The absorptive power of the stomach is surprisingly small. In this also one may see a provision for the protection of the body, for it allows of the neutralization or rejection of injurious substances before they have time to enter the blood. Alcohol, curiously enough, is of all substances, that which the stomach absorbs most readily. This partly explains the rapid action of alcohol. Peptone, sugars, and salts are also absorbed by the stomach. The stronger the alcohol, or the more concentrated the solution of these substances, the greater is the degree of absorption.

There is reason to believe that the process of absorption by the stomach is much more of the nature of a mere diffusion than is the case in the intestine, and the process is accompanied by the pouring out of a good deal of secretion. The practical bearings of absorption in the stomach will be more fully dealt with when we come to consider the dietetic treatment of gastric dilatation.

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[1] Others think that it *is* folic acid.

Digestion in the Small Intestine

When the partially digested food leaves the stomach it enters the first part of the duodenum as a mass where it may remain for a time. Ultimately, either by being pushed on by newly arrived food from the stomach or by contraction of the circular muscles of the duodenum, it is passed into the second portion of the duodenum

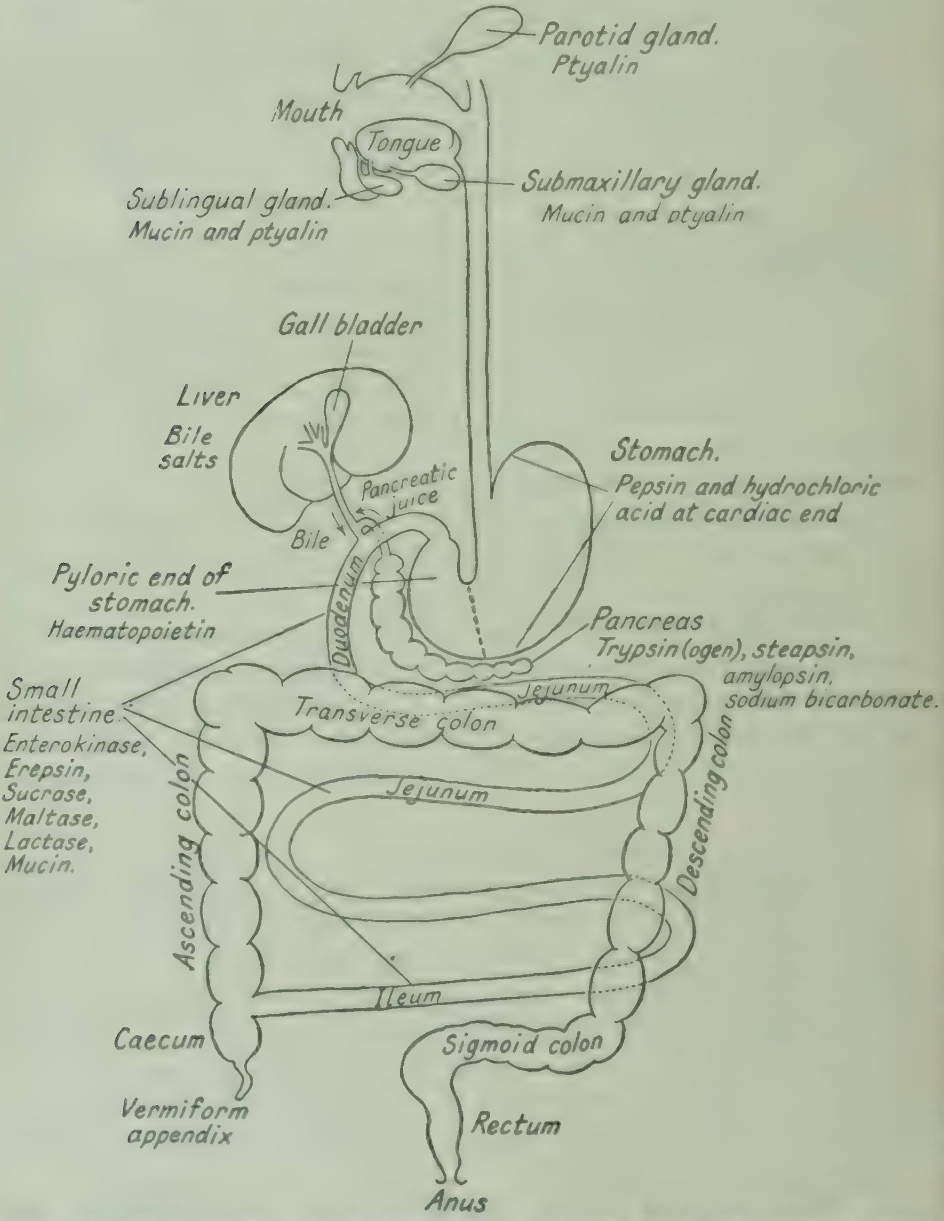
Parotid gland.
Ptyalin
Mouth
Tongue
Submaxillary gland.
Mucin and ptyalin
Sublingual gland.
Mucin and ptyalin
Gall bladder
Liver
Bile salts
Stomach.
Pepsin and hydrochloric acid at cardiac end
Pancreatic juice
Bile
Pyloric end of stomach.
Haematopoietin
Duodenum
Pancreas
Trypsin(ogen), steapsin, amylopsin, sodium bicarbonate.
Small intestine
Enterokinase, Erepsin, Sucrase, Maltase, Lactase, Mucin.
Jejunum
Transverse colon
Ascending colon
Jejunum
Descending colon
Ileum
Caecum
Sigmoid colon
Vermiform appendix
Rectum
Anus

Fig. 11.—Diagram of the Alimentary Canal with the glands which secrete into it.

and is there very rapidly "fragmented."[1] Or the fragmentation may be delayed till the food has reached the jejunum. This fragmentation, due neither to the segmentation nor to the peristalsis seen so well in animals, is probably brought about by the *muscularis mucosœ*, and is obviously of great importance. By its means the food is brought intimately into contact with the digestive juices poured into the small intestine by the pancreas, by the crypts of Lieberkühn and the liver.

The pancreas is partly under the control of the vagus, which, according to J. Mellanby, causes it to secrete ferments,[2] and partly under the influence of the hormone, secretin,[3] which, dissolved by the bile salts in the bile and absorbed into the blood-stream, causes the pancreas to secrete an alkaline juice low in ferments. The crypts of Lieberkühn also seem to be controlled partly by nerves and partly by humoral influences, and the same claim is made concerning the contraction of the gall-bladder which empties the bile into the intestine.

The pancreatic juice contains one potential ferment, and two ferments, steapsin and amylopsin. The proferment, trypsinogen, has to meet the ferment enterokinase of the intestinal juice before it is turned into the very active ferment trypsin. The intestinal juice contains in addition to the enterokinase, erepsin, nucleases, lactase, maltase and invertase; while the bile contains bile salt.

Trypsin digests either undigested or semidigested protein, breaking into the peptide linkages, freeing a good deal of amino-acids but not, however, digesting every peptide linkage. In order to bring all proteins to amino-acids, erepsin is needed to follow up the action of trypsin. It is the function of these two ferments to complete the digestion of protein whether or not it has been initiated by pepsin.

Fat in the human small intestine is probably hydrolysed by the steapsin of pancreatic juice to glycerol and fatty acid, and the latter in the presence of any alkali will become a soap. But there is evidence that fat can be absorbed as such in a highly emulsified form.

Starch, dextrins, and glycogen are hydrolysed by the amylopsin of the pancreatic juice to maltose.

Nucleases attack the nucleic acid of the nucleoproteins and disintegrate them into phosphoric acid, purine bases, carbohydrate, and pyrimidine nucleosides; lactase attacks the lactose of milk and hydrolyses it to glucose and galactose; maltase hydrolyses maltose to glucose; and invertase hydrolyses sucrose to glucose and fructose.

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[1] Barclay. (1936), *The Digestive Tract*, 2nd edn., 162. O.U.P.

[2] Mellanby, J. (1926), *Journ. Physiol.*, **61**, 122, 419, 489.

[3] Mellanby, J. (1925), *Journ. Physiol.*, **60**, 85.

Thus in the small intestine all the foods which need digesting are thoroughly digested into substances which are crystalloidal (and therefore diffusible), and acceptable to the cells of the body which they are intended to nourish. Nothing short of this is of any use, and if proteins or polypeptides or disaccharide sugars get into the blood-stream they either cause disturbance or are excreted unused in the urine.

Absorption in the Small Intestine. Practically the whole of the absorption of food-stuffs takes place in the small intestine. As stated above a small amount of sugar may be absorbed in the stomach, but the amount is almost negligible. All the protein as amino-acids, all the carbohydrate as hexose sugars and all the fat, probably in man as fatty acids and glycerol, which are absorbed, are absorbed in the small intestine. So too are the inorganic salts and the vitamins.[1] Also at least four-fifths of the water drunk is absorbed by the villi of the small intestine. In fact that organ is remarkably efficient in the completeness and the rapidity with which it works.

As we have seen, at least 95 per cent. of digestible proteins, 97 per cent. of fats and 97 per cent. of digestible carbohydrates are absorbed. The figure may actually be higher, because in making this estimate it is assumed that the protein, fat, and carbohydrate in the fæces are derived from the food. This assumption is probably untrue. The nitrogenous material of the fæces may well be derived from secretion of digestive juices and not from the protein of the food and it is not impossible that the fat and carbohydrate of the fæces come from the same source. The " fat " resembles the blood lipoids.

No physico-chemical explanation accounts for the power of the intestinal mucous membrane to absorb materials from its lumen. It absorbs what it wants, or what the body wants, despite osmotic, filtrative, and diffusion gradients which may be working in the wrong direction. But this is not to say that these gradients do not affect absorption. Magnesium sulphate exerts a back osmotic pressure because it is not absorbed and thwarts—hence its aperient action—the attempts of the intestine to absorb water and substances dissolved in water. Meulengracht [2] has even related a failure to absorb calcium from the diet, with a resulting spinal caries, to the use of purgatives. Further, anything which hurries the contents of the small intestine on their way to the colon, e.g. a consumption of large amounts of roughage, may prevent the absorption of the normal percentage of the various constituents of the diet. This largely accounts for the lowered percentages absorbed from a mainly vegetarian diet. Any régime which utilizes large amounts of roughage or purgatives will entail (i) loss of nutrient material to the body; (ii) the passage of unabsorbed proteins, fats, and carbohydrates into the large intestine, with consequences detailed in later paragraphs.

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[1] But see below, p. 246.

[2] *Lancet.* 1938, 2, 774.

Because the secretions of the pancreas and intestinal glands are alkaline it is often assumed that the contents of the small intestine are alkaline or at any rate neutral. This is probably not the case. Samples of human duodenal contents show an acid reaction (p_H between 6 and 7). Also observations of patients with intestinal fistulæ suggest that acidity is usual throughout the small intestine.[1] One of the functions ascribed to vitamin D is that it enables the small intestine to remain acid throughout its length and thus facilitates the absorption of calcium salts.[2] Acidity of the small intestine also increases the absorption of iron. This acidity is due not so much to the failure of the glandular excretions to neutralize the acid of the gastric juice as to the growth of acid-producing bacilli. Through their action upon carbohydrate, acetic, butyric, and lactic acids are produced. In intestinal disorders in which there is an extension of the putrefactive, alkali-producing bacteria of the large intestine, there is a case to be made out for increasing the carbohydrate in the diet, or better still adding lactose which is not easily digested and absorbed and therefore passed further down the intestine unabsorbed than the other sugars. Recourse too may be had to cultures of *Bacillus acidophilus*, one of the normal inhabitants of the intestine. It may be well also to remind the reader again of the value of milk as an intestinal antiseptic.

The contents of the small intestine remain fluid throughout its length; water and substances in solution being absorbed at the same or approximately the same rate. At the lower end of the ileum the amount of solid matter is only 5 to 10 per cent. The advantage of a fluid diet in intestinal ulceration can therefore only be due to the absence from it of things, such as roughage, which would cause mechanical irritation of the walls of the intestine.

Judging from the rate of passage of a meal opaque to X-rays, the ileo-cæcal sphincter is reached 2 to 3 hours after a meal and the cæcum begins to fill at the 4th hour (i.e. at the time of the next meal). At the 6th hour the last of the meal is in the ileum. Consequently the major portion of the digestion of a meal and the absorption of the whole of it is accomplished in the 3 to 4 hours the meal is in the small intestine.

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[1] This generally accepted observation invalidates the theory upon which the Hay diet is based.

[2] By this we do not mean that calcium cannot be absorbed from an alkaline small intestine. A positive calcium balance was observed by one of us (G. G.) in a case of renal rickets when the patient was given heavy doses of alkalis and a large dose of vitamin D.

DIGESTION IN THE LARGE INTESTINE

The contents of the lower end of the ileum pass on into the colon at times related to the taking of the next meal. There is a growing belief that the different parts of the alimentary tract are nervously integrated. Thus the ileo-colic sphincter is thought to open when a new instalment of food passes into the stomach at a meal, and there is some evidence that the pyloric sphincter is also integrated with the ileo-colic. Be that as it may, the cæcum begins to fill 4 hours after a meal, at the 6th hour the head of the meal is at the hepatic flexure but its tail is in the ileum. At the 10th hour all has passed the ileo-colic sphincter and may be in the sigmoid colon ready to be evacuated, or the residue of the meal may accumulate in the transverse and descending colon and only reach the sigmoid colon in the 20th–24th hour. These are of course average figures only—there are great individual variations, particularly in the rate of passage through the large intestine. Often the indigestible debris of the evening meal (e.g. tomato skins) may be voided the next morning, i.e. 12 hours later, and the sigmoid colon reached decidedly earlier.

It will be noticed that there is a considerable slowing up of the rate of passage of the meal in the large intestine. Whereas the first two-thirds of the alimentary tract may be traversed in 4–6 hours, the remaining third *may* take 18–24 hours. Indeed it does by no means follow that all the debris of a meal will be voided either 24 hours, 48 hours or 72 hours afterwards.

The rate of passage through the large intestine is normally increased by vegetable foods either by the mechanical stimulus due to their coarse indigestible fibres or by chemical breakdown products of vegetable cell walls and this has led to the erroneous belief that constipation can be invariably relieved by " roughage." There are colons along which the passage of food debris, etc., is slow because they are atonic (the lazy colons) and colons which allow but slow passage because their circular muscles enter into a spasm (the spastic colons). Roughage still further delays the passage of fæces along spastic colons. X-ray examinations—which according to Barclay are the only certain means of judging (*a*) whether constipation exists, and (*b*) its nature—whether atonic or spastic—show that in from 30–50 per cent. of cases examined the constipation is due to spasticity. Hurst states that the spastic colon is five times as frequent in females as in males.

Antiperistaltic movements in the ascending colon forcing material back into the cæcum, so commonly seen in animals, are absent in the normal human being. The only movements seen are (i) a very slow, small, to and fro movement within each haustral segment, and (ii) sudden "mass movements," as first described by Hurst and by Holzknecht. These latter are important. They occur perhaps three or four times a day immediately after a meal. As a preliminary the haustrations of the colon disappear and the colon walls are relaxed. Then the circular muscles (presumably) contract, beginning proximally, and sweep the column of intestinal contents in front onwards, it may be, for a couple of feet or more. The movement dies out, and the haustrations reappear. The "mass movement" may carry the colonic contents down into the sigmoid colon and on into the rectum, thus sounding the "call to stool." It is probable that these mass movements are related to the taking of a meal and account for the "call to stool" which so frequently is felt soon after breakfast or, failing breakfast, one of the other large meals in the day.

As said above, the contents of the ileum are fluid—they contain some 90 per cent. water. Much of this water is abstracted as these contents pass into and down the colon and the fæces when formed and voided contain about 50 per cent. If the passage has been quick along the colon the fæces will be more fluid and if slow more solid. So long as the diet has been digestible the composition of the fæces is remarkably constant, though the diet may be very varied as regards content. This points to the fæces being derived rather from secretions of the alimentary tract than from unabsorbed food.

But if the diet has been indigestible, has been taken in excessive amount, or swallowed too rapidly for thorough chewing; or if the food has been hurried along the alimentary tract by drugs, irritability of the gut, roughage or food poisoning, undigested and unabsorbed products of digestion will pass into the colon. Here they form a fine pabulum for the bacterial flora of the large gut. Proteins and amino-acids may be broken down and deaminated or decarboxylated to phenols, indol, histamine, tyramine, etc. Carbohydrates may be converted to marsh gas, hydrogen, butyric and lactic acids, and fats to fatty acids and glycerol. The products of protein decomposition are poisonous if (i) they get into the bloodstream, and (ii) they escape the detoxicating influence of the liver. There is little evidence that they ever do, but upon the imaginary evidence that they do were based the mutilating operations on the large gut during the opening years of this century and all the food and medical fads which are centred on the view that the large intestine is a poisonous cess-pool. The undoubted secondary symptoms of constipation—raised blood pressure, headache, nervousness, evil taste in the mouth, and foul breath—are due to distension of the colon and not to toxæmia.

If there are formed elements in the fæces, apart from the large numbers of dead microbes, it is a sign of unsatisfactory digestion. Muscle fibres of the meat eaten should not be present. If they are, food has been bolted, or eaten in too large amounts, or peptic and pancreatic digestion is poor. If starch grains are found it means either that the starchy foods were not properly cooked or that they were hurried along the gut by roughage and purgatives or were enclosed in vegetable cell walls.

In any case incomplete digestion and absorption of foods in the small intestine makes for offensive fluid stools and intestinal distension. The bearing of this upon dietetic habits, cooking, and dietetic hygiene is fairly clear.

Until 1940, research had shown that the large intestine absorbed nothing but water and glucose from its lumen and the possession of such an organ has been somewhat of a puzzle to biologists. The bird has practically none, the carnivores a short one and the herbivores one much longer. Man is in an intermediate position. His intestine is sterile at birth but within a very few hours it is invaded by microbes. If these are dangerous, as Metchnikoff and others have thought, why has such an organ been retained ? Others have maintained that the microbic flora of the large intestine serve a useful purpose, though it was shown by Nuttall early in this century that guinea-pigs can be reared under conditions in which their large intestines remain sterile. Since 1940 evidence has been accumulating that the flora of the large intestine manufacture vitamins of the B complex, that these pass into the fluids in which the microbes are being cultured and are absorbed into the blood stream. Thus man can absorb at times sufficient thiamine, riboflavine, nicotinic acid and probably the other moieties of the B complex from the incubator formed by his large intestine. At any rate these moieties from the large intestine are a very useful supplement of those taken in the food. Confirmatory of these observations are the fact that thiamine, riboflavine and nicotinic acid can be rapidly absorbed from enemata.[1] Microbes of the large intestine can also manufacture vitamin K in adequate amounts for absorption.

Consequently we may consider this production and absorption of vitamins an important function of the large intestine acting as an incubator for commensal microbes, and we can also see a danger in removing it surgically, using bacteriostatic chemicals which will depress the activity of these microbes or adopting a freak diet which may alter the nature of the intestinal flora.

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[1] NAJJAR *et al.* (1943 and 1944), *J. Amer. Med. Ass.*, **123**, 653, and **126**, 357, cited, *Lancet*, (1944), **2**, 854.

Until recently it was believed that the large intestine is an excretory organ for excess of calcium, phosphorus and iron in the blood but to-day this view is discredited as the result of a long series of experiments by McCance and Widdowson.[1] Any of these elements found in the fæces are there because either they have not been absorbed from the alimentary tract or have formed a normal part of the succus entericus.

A summary of the digestion of a mixed meal may serve to gather up a number of the scattered facts which have been mentioned in the preceding paragraphs :

The complex sensation called " hunger " impels one to seek food.

The sight and smell of the food awakens the sensation of "appetite," and with it there begins a flow of digestive juices, most marked in the case of the stomach. The soup, which usually forms the first course, by virtue of its warmth and of the extractives which it contains, accelerates and increases the secretion of the gastric juice. The solid part of the food is chewed to a pulp in the mouth, and unless acid substances are mixed with it, part of its starch is changed into maltose. Arrived in the stomach, it encounters the " psychic " juice already secreted, the acid of which combines with the proteins of the food. In this way the acidity of the stomach contents is kept down, and the action of the saliva upon the starch is allowed to continue. As the solids become digested by the " psychic " juice, their chemical constituents are set free, and themselves begin to excite a secretion fitted for their own digestion.

Meanwhile, the acidity of the contents goes on increasing, and brings to an end any further action of the saliva upon starch; it kills or paralyses many of the organisms swallowed with the food, while at the same time the peristaltic movements of the stomach begin. Under the influence of these the gastric juice and the food are mixed, and the temperature of the mass adjusted to that of the body. As digestion proceeds, the semi-fluid part of the contents, along with any excess of fluid which has been swallowed, finds its way into the pyloric end of the stomach, and by the systolic contractions of the latter is propelled into the duodenum. This process continues for about 4 or 5 hours, by the end of which time the stomach is again empty. During all this time the absorption of alcohol and minute quantities of peptone, sugar, and salts has been taking place.

[1] See, for example, McCance and Widdowson. (1937), *Lancet*, 2, 680.

Arrived in the duodenum, the food encounters the secretion of the pancreas already called out by psychical influences via the vagus, and now increased by the action of the hormone secretin. Here digestion is completed, and as the food is carried along the small intestine its constituents are rapidly absorbed into the blood, or chyle. During this time certain bacteria, which have escaped the action of the gastric juice, are busy breaking up any carbohydrates which may be present, producing from them organic acids, which restrain the putrefaction of the protein constituents of the food that would otherwise be apt to occur. The fluid poured out by the glands of the small intestine in the attempt to neutralize these acids partly makes up for the absorption of water, and causes the contents of the ileum to remain fluid until the large intestine is reached. The absorption of the digestion products of protein, fat, carbohydrate, together with water, inorganic salts, and vitamins takes place in the small intestine. Beyond this point the production of acids ceases, and the rapid absorption of water causes the contents to assume a solid form, while putrefactive bacteria are able to grow unchecked, save by the products of their own activity. Vitamins of the B complex are made by microbes in the large intestine, pass out into the substrate and are absorbed. Finally the residue is expelled in the form of fæces, usually from 8 to 24 hours or more after the food was swallowed.

The respective ***influence of exercise and rest*** on the processes of digestion is disputed. Beaumont, from his observations on St. Martin, came to the conclusion that *gentle* exercise aided digestion, and Hellebrandt and Miles, a hundred years later [1] agree, finding that moderate exercises before a meal increases the acidity of gastric juice ; moderate exercise after a meal decreases it, and exhausting exercise before a meal seriously decreases it. The whole question is probably one of blood-supply. Gentle exercise, by increasing the rapidity of the circulation, may aid the secretion of digestive juices and stimulate the movements of the stomach. Severe exercise, on the other hand, by diverting much blood and nervous energy to the muscles, may be expected to have an adverse effect.

On the whole one can agree with King Chambers, that the best employment after a heavy meal is " frivolous conversation," which keeps the heart active without making great demands upon the brain. Rabelais, Chaucer, and even Solomon may be interpreted in the same direction.

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[1] *Amer. Journ. Physiol.* (1932), **102**, 258.

Metabolism of the Products of Digestion of Food

For a thorough understanding of the principles of dietetics as applied in treatment a few paragraphs upon the metabolism of proteins, fats, and carbohydrates are essential. For reasons which later will become obvious we will start with the *Carbohydrates.*

These enter the bloodstream from the lumen of the small intestine in the form of the hexose sugars, glucose, fructose, and galactose. If lactose gets into the general circulation as the result of the activity of the mammary gland during lactation, it is excreted by the kidneys.

These sugars reach the bloodstream via the portal vein and it used to be stated that in health they were all absorbed by the liver and that the sugar in the systemic blood was not increased after a carbohydrate meal. This hypothesis was disproved as soon as it was possible to estimate the sugar in small amounts of blood, 0·1 c.c. to 1 c.c. instead of 10 to 20 c.c. and therefore to collect the blood at frequent intervals after the meal. We now know that the fasting value of the blood sugar varies from 0·08 to 0·12 per cent. and is the same in the arterial, capillary, and venous blood. The sugar begins to increase in the blood within 10 minutes after a dose of glucose and a little later after a carbohydrate meal, and usually reaches a maximum after 30 minutes. This is about 0·18 per cent. in the capillary blood, say, of the finger, and about 0·15 per cent. in the venous blood of the arm vein. The blood sugar either returns to the fasting value within 1 hour or at the most 2 hours, and the amount in the capillary and venous bloods are once more identical. The difference between the capillary and venous blood after a dose of sugar suggests that the sugar is being stored in the muscles of the limb. This is confirmed by the experiments of Burn and Dale,[1] and Best, Hoet, and Marks,[2] on a decapitated dog which had been completely eviscerated except for the liver. They found that when insulin and sugar were added to the defibrinated blood the sugar disappeared from the blood and was laid down in the muscles as glycogen.

The mechanism by which the sugar is laid down as glycogen in the liver is not yet clear. Goldblatt showed that when sugar and insulin were given to young rabbits the glycogen was deposited in the liver, but showed that this only occurred in very young rabbits. If, however, adrenalin was given to older rabbits simultaneously with the sugar and insulin glycogen was then laid down in the liver.

[1] BURN, J. H., and DALE, H. H. (1924–25), *Journ. Physiol.*, 59, 164.

[2] BEST, C. H., HOET, J. P., and MARKS, H. P. (1926), *Proc. Roy. Soc., London.* Series B. 99, 32.

The path of fructose must be different from that of glucose, for the rise in blood sugar after 50 grammes is not so great as after 50 grammes of glucose. If the blood sugar rises more than 25 milligrammes it is believed that the liver is damaged. This suggests that the fructose is taken up by the liver as it passes through the portal veins in the liver and that only the excess appears in the peripheral circulation. Similarly galactose is rapidly converted into glycogen in the liver, but there is some evidence that the glycogen made from galactose contains 18 glucose units as against the 12 unit glycogen made from glucose.[1]

The belief that glucose, fructose, and galactose play different parts in the body is supported by the observation that the hypoglycæmia produced by insulin cannot be relieved by fructose or galactose, though glucose at once causes the disappearance of the symptoms.

The carbohydrate eaten and absorbed is partly used for supplying the energy of the muscular contraction and any excess is in some way transformed into fat, presumably in the liver, and then laid down in the fat depots, etc.

This does not concern us here any more save to say that in the transformation, a good deal of carbon dioxide is eliminated and excreted by the lungs, thus raising the respiratory quotient. That used for the production of energy is transferred to the tissue which needs it by the bloodstream and there it is oxidized to carbon dioxide and water, step by step by a series of enzymes and coenzymes, involving vitamin B_1 and possibly riboflavine and nicotinic acid.

In the absence of insulin, the internal secretion of the pancreas, the sugar cannot be laid down in the muscles as glycogen and, in some way not understood, the oxidation of the sugar is unable to proceed.

In the absence of vitamin B_1, the oxidation is only able to proceed as far as the stage of pyruvic acid and then ceases.

The end products of normal carbohydrate metabolism are carbon dioxide and water, and these can be very easily eliminated from the body. Sometimes it is true that an intermediate product escapes into the blood and is in part secreted by the kidney. For example, in violent muscular exertion some of the lactic acid, which is an intermediate product of carbohydrate metabolism, gets from the muscles into the blood and, though it should be taken up by the liver and transformed into glycogen again, some of it is excreted by the kidney and so wasted. Also the kidney is involved in the excretion of pyruvic acid in beri-beri. In diabetes the kidney is involved in a twofold way. First it must remove the excess above the threshold of glucose in the bloodstream and secondly it removes the acetone bodies which are due to an arrested metabolism of fat, because metabolizable carbohydrate is needed for the complete oxidation of fat and in diabetes the carbohydrate is not completely metabolizable.

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[1] Bell. (1935), *Biochem. Journ.*, **29**, 2031; (1936), **30**, 2144. See also Stewart and Thompson. (1941), *Biochem. Journ.*, **35**, 245.

Fat Metabolism

Fat is needed for two purposes: (i) as fuel, (ii) because it provides the necessary fatty acids for the manufacture of the lipines, e.g. lecithin, which forms so indispensable a part of nervous tissues, blood cells, and other cells.

Sixty per cent. of the fat absorbed from the small intestine passes by way of the lymph channels (lacteoles, lacteals, and thoracic duct) into the venous blood in the left subclavian vein. It thus avoids the liver on its first circuit of the circulatory system and may in part be laid down in the fat depots for later use. When pork fat is eaten, pig fat is laid down in the fat depots; when mutton fat is eaten, fat characteristic of the sheep is laid down in those depots.[1] Fat manufactured from carbohydrate has more of the nature of the fat that characterizes the animal eating the carbohydrate. What happens to the remaining 40 per cent. is not accurately known. It may also go via the lymph, or it may go direct to the liver. The most modern view is that the hydrolysed part of the fat travels via the portal vein whereas the unhydrolysed fat reaches the blood stream via the thoracic duct. Anyhow, after a meal containing large amounts of fat, the general bloodstream becomes milky and the liver contains an excess of fat, visible under the microscope and estimable by chemical analysis.

Almost certainly the lipines are manufactured in the liver and almost certainly fatty acids undergo many of the steps in their oxidation in the liver. Probably the fatty acids are broken down by two carbon atoms at a time to form acetic acid and the next but one lower homologues. Thus it is presumed that stearic acid is oxidized via aceto-palmitic acid to acetic acid and palmitic acid.

$$\underset{\text{stearic acid}}{C_{17}H_{35}COOH} + O_2 \rightarrow \underset{\text{aceto-palmitic acid}}{C_{15}H_{31}COCH_2COOH} + H_2O$$

$$C_{15}H_{31}COCH_2COOH + H_2O \rightarrow \underset{\text{palmitic acid}}{C_{15}H_{31}COOH} + \underset{\text{acetic acid}}{CH_3COOH}$$

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[1] This is not absolutely true. SCHOENHEIMER. (1942), *The Dynamic State of Body Constituents*, has shown that even in the fat depots, those apparently secluded parts of the circulation, an interchange continually takes place between circulating fats and depot fats and within the depots marked changes occur.

This continues until butyric acid $CH_3CH_2CH_2COOH$ is reached which is oxidized to aceto-acetic acid, as in the parallel case of stearic acid, but then the mechanism breaks down if there be no carbohydrate in the liver or if there is no insulin present to enable the carbohydrate to burn the aceto-acetic acid. The latter either passes as such into the bloodstream, or is reduced by the liver to β-hydroxybutyric acid. These are excreted in the urine and in the urine the aceto-acetic acid passes spontaneously to acetone. This spontaneous change also occurs in the blood.

The three substances, β-hydroxybutyric acid, aceto-acetic acid, and acetone are called the ***acetone bodies***. The acetone is excreted by the lungs and is noticeable in the breath as a smell of sweet apples. In mild cases of *ketosis*, the name given to the state when acetone bodies are being excreted, more aceto-acetic acid than β-hydroxybutyric acid is present in the urine, but in the more severe stages the β-hydroxybutyric increases and forms about 70 per cent. of the total acetone bodies in the urine.[1] Very small amounts of acetone are present in freshly passed urine, but they rapidly increase when the urine stands in a warm place owing to the spontaneous breakdown of the aceto-acetic acid.[2]

In any state when a large amount of fat is being metabolized without sufficient carbohydrate " to take care of it " a ketosis results. Such states are :

(1) When the amount of carbohydrate in the diet is very small, or when the amount of fat in the diet is very large and only moderate amounts of carbohydrate are eaten.

(2) When the patient is vomiting a great deal, e.g. in (*a*) cyclical vomiting of children, (*b*) toxic vomiting of pregnancy, (*c*) post-anæsthetic vomiting, and (*d*) vomiting in the course of zymotic diseases in children.

(3) In severe diabetes when the blood contains an excess of sugar which cannot be used for the burning of the fatty acids.

Whenever, then, we want to check a ketosis we either give large amounts of cane sugar, fructose, or glucose by mouth or we make the blood sugar more available by giving insulin. If necessary glucose may be injected intravenously. In the case of diabetes mellitus we give a sufficient amount of insulin to ensure that the sugar is used.

If we wish to provoke a ketosis, as in epilepsy and cystitis, we greatly increase the fat in the diet and decrease the carbohydrate.

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[1] KENNAWAY. (1914), *Biochem. Journ.*, 8, 355.

[2] FOLIN. (1907), *Journ. Biol. Chem.*, 3, 177.

For this purpose diets with as little as 10 grammes of carbohydrate per day have been devised. See p. 667.

Protein Metabolism

The proteins are absorbed as amino-acids and pass to the liver. If carbohydrate has not been taken at the same meal these amino-acids are used as fuel (exogenous protein metabolism) ;[1] if they are accompanied by carbohydrate they pass to the tissues other than the liver and are transformed into tissue protein or into nucleo-protein or into substances such as creatine and adenylic acid used in muscle metabolism (endogenous protein metabolism).

In ***exogenous nitrogen metabolism*** the amino-acids are deaminated in the liver and transformed either into glucose or into fatty acid. An amino-acid such as alanine will be transformed into glucose by a series of steps simply (probably much too simply) indicated thus :

$$\underset{\text{alanine}}{2CH_3CHNH_2COOH} + 2H_2O \rightarrow$$

$$\underset{\text{lactic acid}}{2CH_3CHOHCOOH} + 2NH_3 \rightarrow \underset{\text{glucose}}{C_6H_{12}O_6} + 2NH_3$$

More than half the nitrogen of the protein of exogenous nitrogen metabolism passes by this path. The remainder passes by the fatty acid path to butyric acid ; thence to aceto-acetic acid and if there be carbohydrate available to carbon dioxide and water. The ammonia formed by each deamination is transformed in the liver to urea, which passing into the bloodstream is excreted by the kidney in the urine. Thus one *main product of exogenous protein metabolism is urea.* The kidney also plays a rôle, for if healthy it is capable of either making ammonia or taking it up from the blood in order to neutralize the acids which have to be excreted by the kidney. When the kidneys are damaged by a chronic interstitial condition it loses this power and the patient may develop an acidæmia.[2] Two pathological products of exogenous protein metabolism are *glucose* and acetone bodies, as in severe diabetes.

We have considered in a previous chapter in the section on acid-base equilibrium two other end products of exogenous protein metabolism—phosphoric and sulphuric acids.

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[1] It will be remembered that the distinction between endogenous and exogenous protein metabolism is not quite so clear as it once was. None the less the older and simpler account of protein metabolism is satisfactory for the purposes of practical dietetics.

[2] LINDER, G. C. (1926–27), *Quart. Journ. Med.*, **20**, **283**.

The bearing of all these considerations will become clear when we deal with diet in nephritis with uræmia or with inability to excrete an acid urine and also when we deal with diabetes.

In ***endogenous protein metabolism*** the body builds from amino-acids such substances as creatine and purine bodies. Oddly enough though it can manufacture these substances from amino-acids it does not seem able to decompose them via the same paths by which it manufactured them. Thus some of the creatine when it has served its purpose in muscle contraction escapes into the bloodstream and is transformed into creatinine and excreted in the urine. And the purines, which can be synthesized from amino-acids and are used in the processes concerned in muscle contraction and in the manufacture of nucleoproteins, are transformed into uric acid when they are degraded and excreted. These purines, adenine and guanine, are oxidized by the liver through hypoxanthine and xanthine to uric acid and the kidney excretes them as urates in man, the anthropoid ape and the Dalmatian dog alone of the mammals.

Two end-products of endogenous protein metabolism are creatinine and the urates. At the same time urea, sulphates, and phosphates will be formed, so that the *whole* of exogenous metabolism is not shown by the urea produced. As meat contains creatine and free and combined purine bodies, and tea, coffee, and cocoa have methyl purines in them, some of which the body oxidizes to uric acid, not all the creatine and uric acid in the urine represent endogenous metabolism. Half of the uric acid excreted on a normal diet is exogenous in origin.

The bearing on dietetics is as follows. The body in gout has difficulty in excreting uric acid. We therefore try to protect it from having too much to deal with (i) by forbidding all foods which are especially rich in purines, e.g. all foods containing many nuclei (see pp. 482 and 612–13); (ii) by reducing the total protein intake of the diet and giving adequate amounts of fat and carbohydrate.

CHAPTER XI

NORMAL DIETETICS

It is time now to sum up the preceding chapters of this book in their relation to the problem of normal dietetics. As has been emphasized earlier, there is no one scheme of diet which is perfect. In the first place we have not as yet reached finality in the subject and in the second we have to make so much allowance for individual idiosyncracy that a hard and fast rule cannot be laid down. We realize that this gives a wonderful chance for the food faddist to find even experimental basis for his practices, but we would call attention again to the fact that what will suit one person should by no means be the rule for everyone. In suggesting dietary standards, as we propose to do, we bear in mind Atwater's dictum that a dietary standard is only an indication and not a rule.

The Number of Meals per Day. The practice of the human race varies in different parts of the world. The Kaffir in the mines of South Africa prefers to work without food and takes one enormous meal at the end of the day. In the majority of countries with a civilization dating back only a hundred years or so it is the custom to take three meals a day. In the longer settled countries the number of meals is often more. Moreover the times at which meals are taken varies with the century and the country. What man does or has done is no guide to the best number and nature of his meals, and appeal must be made to research.

This has been attempted by Haggard and Greenberg[1] in the United States, a country with a settled habit of taking three meals a day. A convincing series of experiments upon laboratory workers, school teachers, children, and factory operatives showed that muscular efficiency, earning efficiency in piece work and freedom from a feeling of fatigue and irritability were best obtained by a schedule of five meals a day, three of them the conventional meals and two smaller meals half-way in between. This work has been followed up by research in absenteeism and relation of food habits thereto. It was found that the careless, eat-between-meals, type of person showed much less absenteeism then the meticulous follower of scheduled mealtimes; that absenteeism was increased by missing meals and that in a controlled experiment when the missing of the meals was purposely schematized the absenteeism followed closely the missing of the meals. The English practice among the well-to-do conforms to this plan if we accept the growing habit of the mid-morning snack. Breakfast, "elevenses," lunch, afternoon tea, evening meal correspond to Haggard and Greenberg's schedule, but the authors make the point that the food consumed at the smaller meals should be of the "protective"[1] type. Otherwise if calorigenous foods only are taken at these meals, the appetite at the meals when protective foods are served will be decreased and there will be a decrease in the consumption of such foods. If Haggard and Greenberg's schedule be adopted the side meals should contain milk and fruit, or, say, the popular egg and cress and the tomato sandwich of afternoon tea in this country.

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[1] HAGGARD and GREENBERG. (1935), *Diet and Physical Efficiency.* Yale University Press.

Nature of Meals. We have already suggested that it is wise not to make any meal predominantly protein, fat or carbohydrate in nature—particularly is it unwise to separate the carbohydrate from the protein. We emphasize this in view of the Hay system of diet which has been well advertised and practised in this country and demands a separation of the carbohydrate from the protein (see pp. 21, 95 and 674).

In fact the advice we would give to a person in any part of the world is to follow the general plan of diet adopted among the better classes in that country, but to see that the protective foods are well represented. The daily quantities of protective foods considered advisable are given in a preceding chapter. *Make sure of the protective foods, take the usual diet of the land and the first-class protein and the Calories will look after themselves.* This plan should work for every adult and for every child in any part of the world. The only precaution that we would suggest in addition is that women should take rather more of the iron-containing foods than is customary in this country.

The feeding of the ***very young*** is dealt with in a later section of this book. The plans there given are the conventional plans adopted by pædiatricians to-day, but it does not follow that they are the last word. Twenty years ago it was the custom to keep infants on milk alone till they were 9 months of age. Now it is customary to introduce them to more solid foods, particularly iron-containing foods from the 6th month. Artificially fed infants need a supplement of iron much earlier. It will be remembered that spinach has fallen from the high position it held amongst dietitians in supplying iron, but other green foods have not been so deposed.

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[1] i.e. mineral element and vitamin containing.

One defence made for this early introduction to a more varied diet than milk alone is that it produces a number of conditioned reflexes at a time when negativism is not well developed, upon which reflexes a sound scheme of diet can be built up later. We particularly commend the consideration of conditioned reflexes to those who have children to feed. By the time a child has reached the age of three it should be willing and able to eat most of the things which an adult takes. We know that there are some who advocate that breast feeding should be continued for a much longer period than is the custom in this country and we do not disagree so long as the child becomes accustomed, along with such feeding, to take many of the solid ingredients of an adult diet.

The transition from a wholly milk diet to the mixed solid diet of a child of three is a particularly difficult transition to make and we believe that many of the life-long dislikes—quite irrational dislikes—of otherwise sensible people are the result of careless handling at this age. The transition should be slow and deliberate. Force should never be used. On the other hand obvious anxiety on the part of the parent that the child should eat the "right" thing is just as dangerous. It is fatally easy to play into the hands of a child's wish to put itself into the centre of the picture of its parents' solicitude and refusal of food is the trump card often played to that end.[1]

Further, we may say that, although we have given advice later as to the types of food which may be used up to the age of three years, we do not mean to imply that these may not be changed as we get to know more about the feeding of the very young. A good case could be made out for dispensing with any cereals, particularly the unmilled cereals, and replacing them with vegetables, particularly potatoes. Alternative suggestions to those appearing in this book are to be found in any modern book on pædiatrics or reference could be made to suggestions based on the general advice given by the Technical Commission of the League of Nations.[2] To-day we can be sure of diets which will produce a respectable result in feeding the very young but we cannot say we know the best diet.

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[1] LIPPMANN, quoted by BRENNEMANN. (1930), *Amer. J. Dis. Child.*, **40**, 1, writes, "With all our weighing and measuring and all our rules and regulations as to when, where, what and how much to feed children, we have succeeded in doing just one thing—we have taken their appetites away."

[2] MOTTRAM. (1937), *Practitioner*, **139**, 63.

The same may be postulated for ***children over the age of three.*** By that time the child may be put on the normal diet of the adult with the premise that the protective foods must be abundantly represented, that rich, highly spiced and indigestible dishes be avoided and that stimulants such as tea and coffee be not given. The objection to tea is that not only is its stimulant action useless to the young but that it is apt to decrease the amount of milk taken. To weak coffee made mainly with milk and to cocoa the objections are by no means as great. Indeed these substances used as flavouring materials will often induce the young to drink milk which they might otherwise refuse. The rule of feeding any child up to the age of puberty is to take care that the protective foods are well represented, use otherwise the normal foods of the British diet and leave the appetite to determine the energy value of the diet.

At ***puberty*** the appetite increases, often enormously, but so long as the diet is kept plain and simple there is little fear of the child taking more than is necessary. Usually the demands of the appetite are met by an increase all round of the foods eaten, but where economy has to be considered there is apparently little harm in allowing an increase only of the foods which produce energy. Thus so long as there are ample protective foods, a diet which supplies milk, bread, butter, sugar, and jam *ad lib.* will probably produce as good a result as one more carefully planned.[1]

The ***adolescent girl*** should be encouraged to take iron-containing foods to an amount equal to or greater than that of her brothers. There is no reason to discontinue the fish-liver oils at this or at any other age.

Diet for the Manual Worker. As the demand of the body of the manual worker is for more energy only there is little need to increase any part of his diet except that which produces energy. There is practically no basis for the common belief that muscular work demands an increase of protein. Meat does not make for muscular energy. In fact, as we have seen, a high protein diet is wasteful in that so much of its potential Calories are frittered away in the specific dynamic action of protein. There is, however, a case to be made out for an increase of two of the vitamins, B_1

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[1] It was difficult during the war of 1939–45 for the adolescent to obtain sufficient calcium, owing to the shortage of milk and cheese. The production under the Ministry of Food of a cocoa-flavoured dried-milk food for adolescents did something to obviate this difficulty.

and C.[1] Manual workers who can carry on with their normal diet when on light work, have been known to develop beri-beri or scurvy on undertaking more severe work. Whether that is likely to occur in this country is not certain, though one of us (V. H. M.) has seen the development of symptoms suspicious of scurvy—they disappeared on treatment with orange juice—which *coincided* with an increase of physical work without concomitant alteration in the nature of the diet.

Usually extra physical work automatically increases the appetite and so the food consumed is increased. If the diet is satisfactory at the low level of intake it will presumably be satisfactory at the higher level. If, however, it is a border line diet as regards its vitamins, or if the increased appetite is satisfied with an increase of such foods as bread, pastry, suet puddings and the like, it is just possible that a subavitaminosis will result. The soundest theoretical plan to meet an increase of physical work would be to increase the sources of vitamins B_1 and C as well as the carbohydrate and fat foods. Bacon, ham, wheatmeal bread as the source of B_1 and oranges, tomatoes, watercress, etc., as the source of C, seem to be indicated.

Diet for the Athlete. There is practically no agreement among athletes and their trainers as to what constitutes the best diet while in training. And until fairly recent days the theories of the dietitian were at variance with the practice of the athlete. The dietitian believes that carbohydrate is the prime fuel for muscular energy; the rowing men used to " eat enormous meals " (mainly meat) and then exercise in order " to work it into them," [2] and cut down carbohydrate in almost every form. But the modern tendency has been towards a simple and more normal average diet of digestible foods taken at regular times with nothing in between meals. Potatoes are still taboo, though for no obvious reason except that of experience and prejudice. Other carbohydrates are by no means eschewed, indeed rowing men and other athletes now swallow one or two tablespoonfuls of sugar just before a strenuous race. Experience seems to show that while this does not alter appreciably their performance in the race it does obviate the exhaustion felt after it for the rest of the day.[3]

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[1] Fox. (1940), *Proc. Trans. Mine Med. Off. Assoc.*, 19, March; (1943), *Lancet*, **63**, 349, from observations on a very large number of Kaffirs working in the mines of Johannesberg entirely denies this as regards C. A theoretical case can be made out for increasing B_1 to keep pace with the increased carbohydrate metabolism.

[2] Abrahams. (1934), *The Practitioner*, **133**, 695.

[3] Private communication from Dr. C. M. Fletcher.

Theoretically, the best plan is to train on a simple and sufficient diet so that the liver and muscles have their full complement of carbohydrate, to rest well for a day or so before the contest on a light diet with plenty of carbohydrate to avoid any depletion of glycogen as the result of nervousness, and perhaps to take sugar, as described above, shortly before the race. Theoretically, too, we should expect an increased need for vitamin B_1 and according to Abrahams [1] this vitamin does seem to enhance efficiency. There is no case to be made out for strict vegetarianism for athletes (it increases flatulence and therefore a tendency to "stitch"), but many long-distance cyclists claim that normal vegetarianism, which allows milk, eggs and cheese, is advantageous. Fluid should not be restricted but, according to Abrahams "enough [water or at least a very bland liquid] should be permitted to make a meal enjoyable, larger quantities may be taken when the stomach is empty; on rising, between meals, and on retiring. Alcohol is quite unnecessary to the athlete."

Mental work influences the amount and nature of the food required in a very different way from muscular labour. It was once believed that the metabolism was raised by some 10 per cent. by mental work. But Atwater,[2] in a careful experiment, came to the opposite conclusion. A man was confined in a respiration calorimeter for a number of days, and on certain of them he engaged in the severe mental work of reading a German treatise on physics. The subject of the experiment was an intelligent person, who fully understood the nature of the experiment, and did not shirk mental application. It was found that on the working days bodily waste was no greater than during rest.

Benedict and Carpenter,[3] in their study of twenty-two young men during examinations, found their metabolism but very slightly higher than when they were performing an equal amount of work that required no mental effort. Grafe [4] concludes, in reviewing the work on this subject, that intense mental effort probably has a positive influence on metabolism, but that so far there are too few experimental data to warrant a definite conclusion.

The next point to stress is that ***there is no special brain food.*** Büchner gave utterance to the dictum, "Without phosphorus there is no thought." This is only true in the sense that the brain contains phosphorus, and without the brain, thought, as we know it, is unthinkable. But it has never been shown that an increased supply of phosphorus in the food is specially favourable to mental effort, nor, indeed, has that been proved for any other food. It requires, of course, no special demonstration that an ill-nourished brain is not one from which good work can be expected : for the brain, like every other organ, demands for its work an abundant supply of healthy blood, and there is, perhaps, no part of the body which is more sensitive to any impoverishment of that fluid. On the other hand, any over-supply of food must be equally unfavourable to mental work. A large amount of food implies a large amount of work on the part of the digestive organs, and that, in its turn, implies a large diversion of blood to the alimentary tract. But if more blood is required in the abdomen, there must be less left for the brain, and the activity of the latter declines, as is evidenced by the feeling of lethargy which is familiar to everyone after a large meal. It comes, then, to this, that *the digestibility of a food is of far greater concern to a brain worker than its chemical composition.* Small and rather frequent meals of easily-digested food is the ideal to aim at. The necessity for this is the more apparent when one remembers that brain work is usually also sedentary work. Compared with the diet of muscular labour, therefore, the diet for mental work should be small. The reduction should probably affect carbohydrates and fats more than protein, for it is the two former, as we have seen, which tend to be specially made use of as energy foods. The protein consumed should be derived to a large extent from animal foods, for these are its most compact and digestible source. Hence it is that it is far easier for a man who is performing bodily labour to be a vegetarian, than for one who is engaged in mental work. Whether an abundant supply of protein has, *per se*, an actually stimulating influence on the brain must be left undecided, though such a view is not without its supporters.

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[1] *op. cit.*

[2] U.S. Dept. of Agriculture. Bull. 44, 1897.

[3] Benedict and Carpenter. (1909). U.S. Dept. of Agriculture, Bull. 208.

[4] *Ergeb. der Physiol.* (1923), **21**, Part 2, 1.

Rest, as is implicit in the paragraphs upon basal metabolism and its relation to total metabolism, requires much less food than work. As we have seen, the basal metabolism of an average man is 1680 Calories per day. This could probably be covered by an intake of food yielding 1900 Calories or at the most 2000. This is a fact of great value in medicine. We can cut down the work, not only of the alimentary tract, but also of heart, kidneys and lungs by 33 per cent. simply by putting the person to bed. It explains, too, why it is that it is so much more easy to fatten a patient when at rest in bed than when up and about ; for in the former condition the demand both for heat and energy is greatly lessened and any surplus of supply can be diverted to laying down of fat or producing growth. It is notorious that a time in bed induces growth in children. The food given during a rest in bed should be of the same nature as that adopted for mental work: simple, digestible, and given frequently, in small amounts.

The dietetic requirements of ***old age*** are just the reverse of those of childhood. The assimilative power of the cells is on the wane and the bodily activities are restricted, hence less food is required. The danger of overfeeding the old is almost as great as that of underfeeding the young; an excess of nourishment chokes instead of feeding the flickering flame of life. Leanness and longevity go together, and a man will only roll all the faster down the hill of life if his figure be rotund. "Discerne," says Bacon, "of the coming on of yeares, and think not to doe the same things still, for Age will not be defied," and one cannot with impunity continue to "doe the same things" in matters of diet any more than in anything else.

The problem is to know how much to take and when old age may be considered to start. The basal metabolism of a number of men of an average age of 80 was only 10 per cent. below the normal.[1] This figure gives us but little guidance to the total metabolism of old men because of the lessened muscular activities of the aged. Figures quoted in earlier editions showed 2149 as the Calorie intake, or about 0·7 of the average man. And this figure is being adopted in recent work concerning the Calorie intake of British families and may well form the tentative basis of any future work.

As regards when old age begins it is difficult to say. Judging from the failure of eyesight and the onset of the menopause old age begins about 45. Tissue metabolism is at its highest point in very early life, so perhaps we may date senescence from 18 months! The curve of basal metabolism falls slowly from its figure of 40 Calories per square metre at 21 years to 35 or 37 at 70 years. In other words, the transition from the metabolism of youth to that of old age is a gradual and insidious process and our food intake should, ideally, in its transition be as gradual. Otherwise obesity is apt to descend upon us as we give up our exercise and resign our bodies to the arm-chair and the motor-car. The fact is that if we are temperate and never continue eating when hunger is satisfied we shall insensibly adjust our intake to the needs of the body.

Luigi Cornaro is one of the most eloquent advocates of temperance in old age. "It cannot be urged too often," he writes,[2] "that when the Natural Heat begins to decay 'tis necessary for the preservation of health to abate the quantity of what one eats and drinks every Day; Nature requiring but very little for the Support of the Life of Man, especially that of an Old Man." He tells us that he ate only 12 oz. of solid food daily, consisting chiefly of bread, wine, broths and eggs, veal, mutton, partridges, chickens and pigeons, and some kinds of fish, such as pike, for "all of these aliments," he adds, "are proper for old men." His system was certainly justified by its results, for he is said to have lived to be a hundred years old.

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[1] Du Bois, *op. cit.*, p. 152.

[2] *Sure and Certain Methods of Attaining a Long and Healthful Life*, translated from the 4th edition; London, 1727, 91.

Woman requires less food than man. Her maximal rate of output of energy is smaller than man's. Her basal metabolism is lower. We should therefore expect her total metabolism to be smaller and observation confirms this expectation. Whereas Lusk allows 2500 and the Technical Commission of the League of Nations allows 2400 Calories per day, the average figure for English women is, as we have stated above, 2100 Calories.

We have no particular recommendations to make concerning the diet of women save that there is no need to depart from the general principle of making sure of the protective foods. Woman probably needs as much of these as man. She needs rather more iron-containing foods than man, and generally speaking her food should be more digestible.

Pregnancy and Lactation. Probably more data on the necessary diet for these two states has been acquired in the last decade than on any other dietetic subject. This is very desirable in view of maternal mortality, which almost certainly might be considerably reduced, and the infantile mortality which though much lower than in the years before the war of 1914–18 has by no means reached the irreducible minimum. Some rather crude experiments in feeding expectant women carried out in the depressed areas of Wales by the Birthday Trust [1] showed a maternal mortality among the better-fed women only one-third that of the controls and an infant mortality, including stillbirths, of only one-half.

There is evidence that the diet of pregnant women should be quantitatively and qualitatively different from that of the non-pregnant woman. Quantitatively the diet is altered by a small but undoubtedly significant increase in the intake of all foods.[1] Thus in Great Britain where the income, less rent, per head per week is over 15*s*. the Calorie intake is on the average about 2500 Calories per day as against the 2100 for non-pregnant women. There is an increase in first-class protein, calcium, iron, and presumably the vitamins as the social scale is ascended. In no case, however, do the average intakes of the calcium, phosphorus and iron reach the levels which experiment suggests are essential. McCance and his colleagues estimate that the daily intakes should probably be of the following order : Calories 2500, protein 90 grammes, calcium 1·5 grammes, phosphorus 2 grammes, iron 20 milligrammes. In the well-to-do classes they found that the actual intakes were : Calories 2500, protein 80, calcium 0·94, phosphorus 1·45 grammes, total iron 14·4 milligrammes (inorganic iron 10·8 milligrammes).

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[1] LADY (RHYS) WILLIAMS. (1938), *Lancet*, **1**, 204. This work has been extended and confirmation obtained of the result of the earlier, cruder experiments. (BALFOUR. (1944), *Lancet*, **1**, 208.) Moreover the experience of the war years 1939–45 has gone to show fairly conclusively that better feeding of pregnant women reduces both maternal and infant mortality. The classes among which the maternal mortality was highest have been much better fed than previously, having been granted cheap milk and priorities with other foods. No country which values the coming generation can afford to drop such preferential treatment.

Perhaps the best way of indicating the qualitative differences which should be aimed at is to give the recommendations of the Institute of Gynæcological Research (University of Pennsylvania).[2]

Non-pregnant Women	Pregnant Women
1 pint of milk per day.	2 pints of milk
1–2 servings of leafy vegetables.	2–3 servings of leafy vegetables.
2–3 ,, ,, other ,,	2–3 ,, ,, other ,,
1–2 ,, ,, fruit.	3–4 ,, (1 or 2 of citrus fruits).
3 slices bread.	3 slices or more (whole grain preferred).
1 serving meat or fish.	Meat or fish as ordered by physician.
1 egg.	1 egg.
1–2 oz. butter.	1–2 oz. butter.
Vitamin concentrates as ordered by physician.	Cod-liver oil or vitamin A, B_1, and D, as ordered by physician.

The comparison in proximal principles or nutrient " elements " works out somewhat as follows :

Calories . .	2000–2600	2000–2600 for first three months. 2400–3000 ,, second ,, ,, Decrease to 2000 or 2200 during the last three months if the gain in weight is abnormal.
Protein . .	1 gramme per kilo body weight.	1 gramme for the first three months, then rising to 1·5 gramme.
Calcium . .	0·55–0·68 gramme.	1·0–2·0 grammes.

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[1] McCance, Widdowson, and Verdon-Roe. (1938), *Journ. Hygiene.*, 38.

[2] Murphy and Bowes. (1939), *Amer. Journ. of Obst. and Gynæc.*, 37, 460.

	Non-pregnant Women	Pregnant Women
Phosphorus .	1·06–1·32	1·5–2·0 grammes.
Iron . . .	15 milligrammes.	18–20 milligrammes.
Vitamin A .	6000	More.
„ B_1 .	300	„
„ C .	300 (? 600)	„
„ D .	400	„

These recommendations are by no means impossible of achievement. Several of the women investigated by McCance, Widdowson and Verdon-Roe either achieved them or came near to them. Significantly enough nearly everyone who did this belonged to the class with over 40*s*. per week per head after making deduction for the rent—i.e. belonged to the wealthy or intellectual classes. Such a diet is not cheap. Because of the large amounts of vegetables consumed, it takes time in preparation. One criticism we make of the diet is that cheese is unrepresented. It might well replace some of the milk, meat or fish. Another is that the protein is too suddenly increased. Increases of all foods should be gradual.

Diet for lactation should follow the lines of diet in pregnancy, but the calcium should be increased.

The estimates of the National Research Council of the U.S.A. are as follows:

Pregnancy (during the latter half) Calories 2500; proteins 85 grammes; calcium 1·5 grammes; iron 15 milligrammes; vitamin A 6000 I.U.; thiamine 600 I.U.; riboflavine 2·5 milligrammes; nicotinic acid 18 milligrammes; ascorbic acid 100 milligrammes; vitamin D, 400–800 I.U.

Lactation. The Calories are raised to 3000; the protein to 100; calcium to 2 grammes; vitamin A to 8000 I.U.; thiamine to 767 I.U.; riboflavine to 3·0 milligrammes; nicotinic acid to 23 milligrammes; ascorbic acid to 150 milligrammes, while the iron and vitamin D are left at the pregnancy value.

Diet for Different Climates and Seasons.

The influence of climate, and especially of a warm climate, on the amount of food required is commonly exaggerated. It seems natural to suppose that, if the surrounding temperature is high, the amount of heat required to be produced in the body will be less. But this is to lose sight of the fact that the temperature of the body is chiefly regulated by physical, and not by chemical, means. To put it more plainly, we adjust the temperature of our bodies not so much by means of increasing or diminishing the amount of heat we produce, as by the simple expedient of regulating the amount of heat lost, i.e. by altering the amount of clothing and the ventilation of rooms.

Heat and life, as has been already pointed out, are inseparable. Whenever work is done, as when the heart beats, not all the energy obtained by oxidizing carbohydrate is utilized in doing that work. Some—and it is an amount equal to two or three times that of the work done—has to be wasted. Now, thanks to the fact that we wear clothes, our bodies live in an atmosphere of about 90° F.—that is to say, in what is practically a tropical climate. At this temperature the amount of heat produced in the body is in excess of that necessary to keep the body temperature at 37° C. (roughly 98·6° F.), even when that production is as small as is compatible with the full activity of our cells. This means that, even in a temperature of 90°, we must constantly waste heat. Suppose, now, that one goes into the tropical regions. As the external temperature rises, the heat lost by the body, because it is at a higher temperature than its surroundings, becomes less and less. Consequently there is still greater excess of heat to be got rid of. One can adjust the balance either by eating less food, or by increasing the loss by wearing thinner clothes and increasing ventilation. It is fairly clear that, supposing one's dietary is an average diet, it is a sounder policy to increase the loss of heat rather than to decrease its production by eating too little food. In harmony with this, one finds, as a matter of fact, that the consumption of food by the inhabitants of the tropics is not notably less than that of those who live in the temperate zone. We find, too, that basal metabolism is but little altered in tropical countries. For instance, Eijkmann found that the basal metabolism of Europeans living in Batavia was 40 Calories per square metre per hour.[1] Others have reported a slight fall after some months' residence. As the basal metabolism falls but slightly if at all, a life involving much muscular effort in the tropics must entail the same intake of food as in temperate regions.

This is not to say the intake of the *same* food, as there are good reasons for a deliberate change of dietary régime to suit tropical conditions. That people crave for different food or less food in hot weather or in the tropics is notorious. Appetite fails and is stimulated by recourse to violent condiments and alcohol. And it is here that considerations of physiology and dietetics may help in suggesting a diet for the tropics.

First of all, we know that in hot weather the bloodvessels of the skin are dilated to allow of greater loss of heat, and therefore brain and alimentary tract are deprived of their normal supply. Second, there is a fall of arterial blood pressure of some 10 mm. Hg possibly as the result of this vasodilatation in the skin. Third, if the temperature of the atmosphere rises to blood heat all the loss of heat must be due to evaporation of perspiration. Fourth, protein foods and notoriously animal protein foods provoke a production of heat of no avail for muscular energy. This heat has to be lost in surroundings hotter than the body and therefore by evaporation of perspiration. Fifth, the cooling power of the air depends on its percentage saturation with water vapour and its velocity, so that if the air is near its saturation-point and still, it is very difficult to lose heat from the body.

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[1] EIJKMANN. (1921), *Jour. d. Physiol. et d. Path. Gen.*, **19**, **33**.

Putting all these facts together, we reach the conclusion that in hot climates the diet should be modified by greatly increasing the fluid intake to allow of profuse perspiration ; [1] by cutting down the intake of animal proteins which have a high specific dynamic action and replacing them by vegetable proteins which have a lower ; by spreading the proteins over the different meals of the day to decrease the specific dynamic action and by using easily digested foods and avoiding those of high satiety value.[2] To transfer the dietary habits of temperate regions to the tropics is to court disaster. Much could be done by regulating the temperature of dwellings by refrigeration, ventilation, and air conditioning to render conditions of life more physiological. What is true of the tropics is true also, but in a less degree, of summer conditions in a temperate climate.

Suppose, on the other hand, that one moves from a temperate to a *colder* latitude. The body will now require more heat to keep its temperature up to the normal level and this is achieved by diminishing the heat lost, mainly by an increase of clothing. If the external temperature falls still farther, however, this method by itself becomes inadequate, and steps must be taken to increase heat production ; it is only then that it becomes advisable to consume more food.

" During the whole of our march," says Sir John Franklin, in describing his journeyings in the Arctic regions, " we experienced that no quantity of clothing could keep us warm while we fasted, but on those occasions on which we were enabled to go to bed with full stomachs we passed the night in a warm and comfortable manner." Translated into physiological language, this means that the demand for heat in the body was so great that it could no longer be met by diminishing loss, but that the deficit had to be made up by an increase of heat production—i.e. by a greater consumption of food. The blood supply to the skin is cut off to conserve body heat when there is too little food and a man feels cold. Extra food enables the skin to have blood and the man feels warm.[1]

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[1] Because of the loss of sodium chloride in the perspiration it is advisable that slightly salted water be drunk instead of plain water. Deprivation of sodium chloride is known to lead to cramp of the muscles. See also Morton. (1932), *Proc. Roy. Soc. Med.*, **25**, 1261.

[2] Inquiry of dietary habits among the well-to-do in India shows that these suggestions are by no means adopted.

What form the increased consumption of food takes is, comparatively speaking, of little moment. All that is really necessary is that the number of Calories which the diet is capable of yielding should be considerably raised. As a matter of convenience, however, and in order to avoid overfilling the stomach, it is best to have recourse to fat as the principal source of the extra heat required, for fat is the compactest form of fuel we possess.[2] Carbohydrates would serve the purpose equally well so far as the cells of the body are concerned, but one would require to consume more than twice as much of them as of fat in order to obtain the same amount of heat. Besides, in very cold latitudes carbohydrates are not so easily obtained as fat.

The influence of *season* on the amount and quality of food required is similar in kind to the influence of climate, though less in degree. In summer, clothing should be diminished rather than food ; in winter, warmer clothing should be worn.

In hot weather the inclination is to eat less food, and if this instinct is followed there will probably be a loss of weight. If the normal winter diet be taken in disregard of the desire for food, the body-weight is maintained, but health is apt to suffer. The probability is that while the amount of food taken should yield approximately the same number of Calories, the nature of the food may as well be altered in the direction the appetite suggests. Thus, hot beef-fat is repulsive in hot weather, especially with the usual accompaniments to roast beef, baked potatoes, and Yorkshire pudding ; but cold beef with its fat intact served with a salad and a French salad dressing, yielding just as many Calories, is appetizing. Amounts of fat which would appear impossible to consume as hot mutton-fat are quite palatable and digestible in the form of butter, cream, or ice cream.

Probably too there should be less animal and more vegetable protein consumed, and the protein not concentrated into one meal as is too often the custom. The specific dynamic action of protein should be avoided, and the animal protein taken at a time when that action causes least trouble.

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[1] It is questionable if Scott's rations on his last expedition were adequate.

[2] An interesting observation made by Stefánsson is that each time on his return from the Arctic he was subject to digestive upset. " . . . When you have been for months on a diet of meat you almost always feel under the weather for two or three weeks after coming back to a mixed diet. I imagine the reason to be that meat is such a bulky food that the stomach gets accustomed to large quantities. Then when you eat the richer ' civilized ' food and fill the stomach as much as you used to with meat you overload it."—*The Friendly Arctic*, 373, Macmillan & Co.

A heavy meat meal at noon will be showing its specific dynamic action in the afternoon at about 3–4 p.m.—i.e. the time when the day is apt to be most oppressive. Unless the nights are hot, meat at the evening meal is not amiss. On the whole the general rule is that animal foods should be more sparingly consumed in summer, and the proportion of vegetable matter in the diet relatively increased. The demand for hot foods and drinks in cold weather and cold foods and iced drinks in hot weather has more psychological than physiological or instinctive basis. A litre (1¾ pints) of iced water will subtract but 37 Calories from the body and an equal quantity of a hot drink, swallowed at 45° C., will add but 8 Calories. Such amounts are a bagatelle.

Influence of Personal Peculiarity. There is a widespread impression that some people can " get on " with less food than others, even though they are living under identical external conditions. There are those of whom it is said that their food " does them no good," while there are others who without eating much put on weight. There is ample evidence of this from work already quoted : that on the intakes of 63 men and 63 women.[1] And there will be still more evidence when Miss Widdowson's observations on the food intakes of over 1000 children are published. At any age there are children taking twice as much or more of some proximal principle of diet than others at that age. Nor will the high or low intakes appear to be related to stature, weight or health. This observation has troubled the dietitian and is still troubling him.

That there is a norm for weight corresponding to height and age is clear from the data of insurance companies, and a marked departure from the norm (say over 10 per cent.) is viewed with suspicion by their medical officers. There is evidence from insurance statistics that it is better to be overweight than underweight in the twenties and underweight than overweight in the forties and later.

The majority of people, who do not have to trouble about their figure, have an astonishing power of regulating their body-weight. For example, as Du Bois has pointed out, a man at 40 years of age may weigh exactly to within a pound or two what he weighed at 20.[2] The balance of intake and output has been adjusted in his case over the twenty years to an error of less than 0·05 per cent. Supposing that he were to lay down and not combust over that period 8·9 grammes of fat per day (the equivalent of a small pat of butter) he would double his weight in twenty years. Some method of regulation of body-weight must prevent such an appalling catastrophe and the wonder is that so few people are obese.

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[1] Widdowson. (1936), *Journ. Hygiene*, **36**, 269 ; Widdowson and McCance, *ibid.*, **36**, 294.

[2] Marrack. (1942), *Food and Planning*, reports the same of himself, and one of us (V. H. M.) can confirm the statement for his own body

The mode of control is still obscure. It is possible that body-weight is regulated by appetite. A well-fed person is more energetic than one underfed and possibly consumes the extra food he has taken in the output of extra energy. Moreover, the specific dynamic action of food rises if there is a surplus and the excess of combustible material is got rid of in this way. On the other hand, an underfed person restricts his activities and so adjusts his output to his intake. If this underfeeding continues the food which is taken, particularly the protein, is utilized in the renovating of depleted tissues without evoking any loss due to specific dynamic action. In the normal person there would be an increased appetite which, when sufficient food became available, would repair the losses due to previous under-nutrition.

We have to remember, too, that there is an interplay of the endocrine glands. Excess of thyroid activity leads to a lowering of the body-weight ; defect of activity to an increase. Defect of pituitary activity unbalanced by an increase of thyroid activity may lead to a gross deposition of fat. Islets of Langerhans in the pancreas [1] and the cortex and medulla of the suprarenal also control metabolism, and the internal secretions of the gonads apparently influence it as well. Some, if not all, of these endocrine tissues are under the control of the central nervous system.

As a working hypothesis we may assume that the regulation of intake and body-weight is carried out by means of a complex mechanism in which appetite, specific dynamic action of food, the endocrine organs and the nervous system are all involved.

If we accept bodily activity as an index of the irritability of the nervous system we can see why it is that some people need a greater intake of food than others. In a series of observations reproduced in the Food (War) Committee's report the Calorie intakes of three boys, one very active, one active and one very quiet, are shown. A reference to Fig. 12 will show that the very active boy at 15 years of age is taking double the amount which the very quiet

[1] The elderly diabetic is frequently overweight at the beginning of the disease and the young diabetic on insulin usually takes considerably less than 2500 Calories per day and yet maintains his weight.

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for about forty years while the other (G. G.) eats considerably less in order to avoid gain of weight.

boy takes and one and a half times that taken by the active boy. The influence of the nervous make-up of the boys considered is obvious.

Pavlov considers from his study of conditioned reflexes in dogs that we can find the Hippocratic "temperaments" reflected in his animals, and that in the large central group of well-balanced temperaments there are to be seen the "phlegmatic" and the "sanguine."[1] The one is quiet, self-contained and sedate, the other lively and active. If we translate these observations on dogs to man we can see how the lively "sanguine" temperaments will need more food to maintain body-weight than the quiet "phlegmatic" temperaments. In fact, the explanation of the observation of the opening paragraph of this section lies probably in temperament or inherited constitution of the nervous system, coupled with the possibility that the differences in intake and output are due to differences of weight, build, shape of body and occupation. The declining activity of body when middle age is reached probably accounts for the increase in weight commonly observed at that time. The body has become accustomed to a large intake to support the demands of youth and is loath to give up its food habits although activity no longer demands such an intake. Du Bois calculates that a decrease in activity comparable to walking 1⅓ miles per day might result in the deposition of nearly ⅓ oz. of fat per day, or 7·17 lb. in a year.

We may take it that individual make-up (nervous and endocrine) does explain idiosyncrasies of food intake. This warns us of the dangers of dogmatism in matters of diet. We can and may lay down rules as to the kind and amount of food required in different circumstances for the average person but we are treading on dangerous ground when we come to apply these rules to individual cases. In the matter of diet every man must, in the last resort, be a law unto himself; but he should draw up his dietetic code intelligently, and apply it honestly, giving due heed to the warnings which Nature is sure to address to him should he at any time transgress.

Psychology and Diet. In the last paragraph a statement has been made which might open the way to every food fad from the days of Genesis to the present day. It comes perilously near the motto of Theleme in Rabelais: "Fay ce que vouldras" or "Do what thou wilt." Although the subject has been lightly dealt with in the opening chapter, it must be discussed again. The problem is: how far is dietetics a rational subject and how far the private psychologies of individual people can upset, do upset and should be allowed to upset its principles. That the origin of food habits is largely psychological has been pleaded at length by Renner—and also that it is rightly so.[1] It is this view which must now be questioned.

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[1] Pavlov. (1928), *Lectures on Conditioned Reflexes*, 376. Martin Lawrence.

There are two definitely opposed schools of thought on this subject. The one maintains that instinct is a guide [2] towards the food needed. The other school, on the contrary, believes that a man's choice of food is not governed by instinct but by his upbringing. For convenience we may call the two schools the Lloyd and the Pavlov schools after their chief exponents. The Lloyd school says that food which you like is beneficial to you. Expanding the ambit of this thesis, it holds that choice of food is governed by instinct, and as instinct is fundamental, that such a choice is natural.

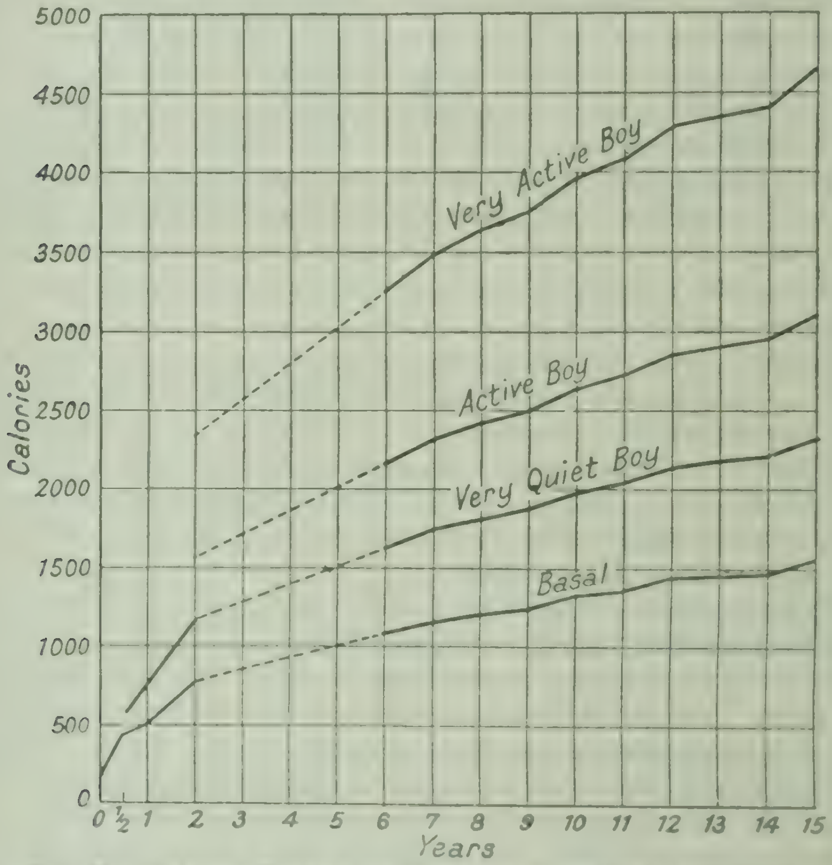

FIG. 12.—CALORIE INTAKE OF BOYS OF DIFFERENT ACTIVITIES.

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[1] RENNER. (1944), *The Origin of Food Habits*, Faber & Faber, London.

[2] Though surely not an infallible guide!

The Pavlov school insists that food habits are the result of conditioned reflexes. That is, we are born only with one food reflex, i.e. of sucking milk and that all the other food reflexes are acquired and built upon this one simple innate reflex. Consequently food habits are the result of upbringing, the adult who likes and eats all foods being well educated and the one with violent likes and dislikes being badly educated. Further corollaries are that such likes and dislikes are a bar to sound principles of dietetics and that the only conditioned reflexes a person should have towards food is those of eating it,[1] masticating it, salivating on it, swallowing it and digesting it. The Lloyd school encourages food likes and dislikes; the Pavlov school frowns on them.

Now everyone would prefer the Lloydian school to be correct. It supports one's natural (or unnatural) weakness for this, that and the other food or drink. It makes one feel a fine fellow in insisting, say, on pepper from a pepper mill rather than a caster, or on a dry wine with the fish and meat courses and a sweet wine with the dessert, or on the order of the courses of the modern international dinner.[2] One feels that one is following the dictates of instinct and that one is in harmony with the great purposes of Nature.

In favour of the Lloydian school there are sundry vague beliefs which rarely bear investigation plus, it must be admitted, some sound observational work. We are told that dogs eat grass to make themselves vomit when the alimentary tract is disturbed; that deer and cattle walk miles to a salt lick, and that ponies in the salt mines of Cheshire lick through the walls of their stables; that animals deprived of adequate phosphorus in South Africa gnaw the bones of their dead comrades (and die of a form of botulism!). All these are observations on animals and have little to do with the case, for in man, with the dawn of reason, it is contended that instinctual guidance declined, and though animals *may* be guided by instinct in the choice of food (but see below), man is not necessarily so guided. Besides, the salt lick story and its supposed foundation on the need for sodium in cattle on a diet too rich in potassium, has been very shrewdly and justifiably criticized by Stefánsson.[3] The *Lamsickte* of South African stockraisers can be explained by a euphoria produced by eating bones; and the fact that horses and sheep in those parts of South Africa do not gnaw bones, though lacking phosphorus, hardly supports the instinctual guidance of the cattle.

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[1] Perhaps the person who maintains that all food is good, but that some is better than another, would be tolerated by the rationalist school of dietitians.

[2] See *Food and the Family*, Chapter 9, by one of us (V. H. M.).

[3] STEFÁNSSON. *Adventures in Diet.*

Turning to human beings, it is said that the pica, i.e. desire, sudden and inexplicable, for unusual foods shown by pregnant and lactating women, that the passion for sugar evinced by children, that the loathing for tinned foods on the sides of Everest, are an evidence that instinct is taking a hand and guiding the human race to the right choice of food.[1] The characteristic of pica in human beings is its utter irrationality. The passion for sugar in children is a passion for strong and lasting pleasant sensation and is by no means invariable and depends largely on upbringing. Children who have not suffered under a Puritanical régime are not particularly keen on sugar—at least that is the fact with the children of one of us (V. H. M.). The observation on mountain climbers are not germane. Modern dietetics no longer frowns upon tinned goods. Tinned foods are not " bad for you," and avoidance of, or hatred for, tinned foods at high altitudes is not, therefore, an instinct towards dietetic sanity. Besides, one result of low bloodsugar and want of oxygen at high altitudes is an irrationality and fickleness of desire. Finally it is customary to quote that astonishing American experiment on allowing babies from 6 months onwards to 18 months to choose what they would to eat as evidence that what babies fancied did them good. It did. But the babies were allowed to choose *only* from protective foods. Their choices followed no pattern nor order, nor was there any invariable sequence followed, upon which could be based a scheme of dietetics for the toddler, let alone for older children and adults. A baby might one day choose to eat four or five eggs only for its evening meal ; at another time the choice might be liver followed by a pint of orange juice. We simply *do not know* what their choices would have been if cream buns, cakes, ice cream, fried fish and pickles had been on the menu. The experiment merely tells us that if one's fancy roams among the protective foods one comes to no harm but, rather, to good.

The only sound experiments concerning man in support of the Lloydian hypothesis we have come across are those by Carlson on Vlček, the Bohemian laboratory assistant, who had a surgically made gastric fistula in consequence of a boyhood's mistake in drinking caustic soda, with a resulting occlusion of the œsophagus. Vlček had a great liking for sweets, desserts and so on, with a dislike of acid or bitter foods. In the course of experiments upon his gastric juice it would be found that when he had had a sweet course at the college caféteria which he particularly liked, the digestive capacity of the juice secreted was high. If his lunch bored him, it was low. Similar observations were made by the Pennsylvania School of Medicine on medical students. If the food were pleasant to eat, served daintily and in pleasant surroundings, 50 per cent. of the students secreted more and stronger gastric juice than when food was indifferently cooked, served on chipped china, on a newspaper for tablecloth, in a dismally lighted cellar! (Curiously enough, the other 50 per cent. were not affected by surroundings.)

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[1] As an aside, is it not fair to say that in view of xerophthalmia, beri-beri, pellagra, scurvy, rickets, osteomalacia, chlorosis and osteoporosis, instinct has made a bad miss in guiding human beings to the target of sound diet ?

Now clearly, unless a man is a hyperchlorhydric already, what he fancies is going to be digested better than what he does not fancy. The evidence so far extends only to gastric secretion, but it is probably true of pancreatic, biliary and intestinal secretion and therefore of total digestion and absorption. Everybody must admit that foods which one fancies call out more and better digestive juices than things which one dislikes. The moral, however, is not that one should eat only what one likes, but should like what one eats.

Richter in his Harvey lectures published in 1943 sums up a series of experiments, mainly upon rats, which seem to show that they have an instinctive choice of the food which would benefit them. Animals with a diet low in phosphorus make for one with a high content when given the choice.[1] A whole series of experiments with definitely deficient diets were given and in every case the animals seemed to know, when given the choice, which food would be good for them. In no case, however, except perhaps one to be mentioned later, does Richter give an example which can be unhesitatingly accepted and cannot be explained on the grounds of a euphoria caused by eating the " right " thing. We have mentioned, *en passant*,[2] a series of illuminating experiments on the choice of foods by the laboratory rat. If you " run him out " of B_1 and then give him a choice of foods with and without B_1, he will choose the food containing B_1. But if you flavour the B_1-containing food with cocoa and later transfer the cocoa to the food without B_1, he is fool enough to transfer his affections also. He now eats a food which could do him no good. Instinct has not told him where the B_1 lies. He fancies the food which contains no B_1.

Between foods which contain or do not contain vitamin A he shows no inerrancy of choice. The explanation the experimenters give is as follows. When an animal is "run out" of B_1 a chance choice of a food containing B_1 allows of recovery from symptoms within a few hours. The animal "feels" better as a consequence of eating B_1 food. He has a euphoria just as a man has after taking a glass of beer or a dose of morphia. But the effects of vitamin A cannot be perceived so suddenly; consequently an animal cannot relate cause and effect and will eat food without vitamin A in it readily enough, though his body is deficient in A. Now it is quite likely that Richter's experiments can all be explained on the lines of producing a euphoria, a well-being of the animal which he associates with a particular food.

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[1] This has not been the experience of other workers. See McCollum, Orent-Keiles and Day. (1939), *The Newer Knowledge of Nutrition*, 161.

[2] Harris, Clay, Hargreaves and Ward. (1933), *Proc. Roy. Soc. B.*, **113**, 31.

There is one exception. Experiments with children in Baltimore on giving them a chance of taking cod-liver oil showed (unexpectedly, surely) that they availed themselves of the choice, but that later in the year they dropped taking it. The assumption by Richter is that they needed vitamins A and D, chose the food which contained those vitamins and then when their stores were adequate, dropped it again. Much more information is needed about the methods of carrying out this experiment, the previous histories of the subjects and the psychological surroundings of the experiment, before it can be accepted as proving that instinct, or need, is a guide, an accurate guide, to what foods should be taken.

Now the case for food habits being conditioned reflexes is based partly on Pavlov's observations on the alimentary conditioned reflexes of dogs and on observations of anthropologists such as Stefánsson and Margaret Mead on the habits of races with whom they have come into contact. Pavlov and his colleagues have shown that the mere lapse of time may act as a conditioning stimulus. Animals accustomed to be fed every half-hour salivate every half-hour, even if the food is withheld at that time. The human being behaves in the same way, e.g. a patient treated for gastric ulcer by feeding every half-hour with minced raw meat soon develops hunger contractions at half-hourly periods. People can train the large intestine to produce rush peristalses and a defæcating reflex at almost any chosen time in the day, so there is nothing sacrosanct about meal-times.

Puppies brought up by hand on milk have to be taught to obtain a conditioned reflex for meat eating. This strange observation had been made by one of us (V. H. M.) before coming across Pavlov's work. Stefánsson observed complete parallels with this in his sleigh dogs in the Arctic Circle independently of Pavlov. Dogs, brought up on fish, refused caribou or wild goose meat, but could be trained to eat them by methods similar to Pavlov's mode of building conditioned reflex upon conditioned reflex. One of us (V. H. M.)

trained children to eat new foods by exactly similar means. Finally, Pavlov showed that even the vomiting reflex in a dog could be evoked by such a stimulus as preparing the skin for the subcutaneous injection of morphine or apomorphine. In man we see an exactly similar reflex. Who, having been sick after eating a certain food, has not been nauseated by that food for a season after the incident, even for the rest of a lifetime ?

Scattered up and down in Stefánsson's writings are example after example of the Pavlovan conditioned reflexes in man and dogs, although he could not have known of this work at the time. We quote the following from Stefánsson's *Friendly Arctic* (1912) :

> A rule with no more exceptions than ordinary rules is that people like the sort of food to which they are accustomed. An American will tell you that he can eat white bread every day, but that he gets tired of rice if he eats it more than once or twice a month, while a Chinaman may think that rice is an excellent food for every day but that wheat bread soon palls. An Englishman will tell you that beef is the best meat in the world, while in Iceland or in Tibet you will learn that beef is all right now and then, but mutton is the only meat of which you never tire. If a man is brought up on the west coast of Norway or on Prince Edward Island, he thinks that herrings and potatoes make the best of all staple diets, while an Iowa farmer likes potatoes well enough but would balk at the herring.

Margaret Mead in *The American Character* (1944, Penguin Books) makes a similar statement about Hungarian children evacuated to the United States. And we add to this the fact, mentioned before, that Bengalese, used to rice, will starve to death during a rice famine rather than eat the wheat imported by a paternal Government.[1] Examples of the conditioning of children to food reflexes will also be found in Renner's book already quoted.

The apparent exceptions to the generalization that it is education and not instinct which determines food habits are that appetite seems to be some sort of a guide to caloric need and, as already mentioned in the first chapter, that the Akikuyu women eat more of the calcium-containing foods than the men.

It is difficult to admit that instinct plays much, if any part, in determining the food habits of man, and if this be so the need for early training to take a mixed diet with a large number of foods represented in that diet becomes paramount. To-day every country is very far from inplementing the need for such education, but until it is so implemented the practice of a rational dietetics will limp along a road made difficult by inculcated or acquired prejudice.

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[1] As this book was going to press a most important publication appeared containing confirmation of the views expressed above. *M.R.C. Special Report Series* 254.

Economy in Diet. No consideration of diet is complete without some reference to economy. It is easy to devise a diet which shall be satisfactory if no regard is paid to its cost, but we have too frequently to prescribe for those whose pocket is not deep. Theoretically it is easy to estimate the minimum cost of a diet which shall give at least the minimum Calories, protein, inorganic elements and vitamins by the following procedure. Take the food which will give the protein ration at minimal cost; make up the Calories by the food which produces Calories most cheaply and then add any cheap food which will make up any vitamin or inorganic deficit. Such a diet will be found in 5 oz. cheese; 2¼ lb. of bread; and some green food, such as 4 oz. cabbage, to make up the deficit of vitamin C, and one teaspoon of liver oil to give vitamin D. The bread must be national, otherwise the diet would be deficient in vitamin B_1. Such a "subsistence diet" would contain 113 grammes protein (35·5 first-class protein), 1·714 grammes calcium, 1·617 grammes phosphorus, 18 milligrammes iron, 4585 I.U. vitamin A, 1·8 milligrammes thiamine, 56 milligrammes vitamin C and 700 I.U. vitamin D. Its cost on the retail market in a town of over 100,000 inhabitants in 1945 was about 1*s*. per day or 7*s*. per week. That is a figure which economists, social workers, and politicians must bear in mind. Any alteration of this impossibly dull and monotonous diet to make it a possible and acceptable diet will cost more. How much more is a question for discussion.

A British Medical Association Committee reported on this subject in 1933, and as dietetics has advanced since that time has brought the report up to date and published a book of menus and dishes which will supply a satisfactory diet at low cost. Their latest publication to date is the Doctor's Cookery Book (price 4*d*.). It is estimated[1] that the diet therein advocated costs 21·3 per cent. more than the cost at the 1933 prices, and on their original calculation this would bring the 1938 cost to 7*s*. per week. In March 1940 it was nearly 8*s*. 6*d*. The cost for a family of man, wife, and three children of school age was 27*s*. 4½*d*. per week in 1938. In March 1940 it was 34*s*. 3*d*. approximately.

This report has been widely accepted by the regional surveys made in such neighbourhoods as Merseyside, Bristol, and Southampton and it may be that in time politicians will accept it as a basis for considering the nutrition of the nation. Students of one of us (V. H. M.) worked out the minimal cost of an adequate diet for February 1944 in Leicester as follows:

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[1] (1938), *Brit. Med. Journ*, **1**, 1326.

Child of 4	5s. 2½d. per week
,, ,, 8	7s. 7d. ,, ,,
Girl ,, 15	10s. 2d. ,, ,,
Boy ,, 18	10s. 9d. ,, ,,
Moderately active adult .	10s. 3½d. ,, ,,
Pregnant woman . . .	10s. 1½d. ,, ,,

The principles upon which we must proceed in building an economical diet are as follows:

First. It is no economy, but rather the reverse, to stint the protective foods. These are often omitted from the diet of the poor because they are supposed to be expensive. Relatively some of them are: e.g. milk and eggs. The price of milk, 9*d.* quart for most of the year, is, we feel, high and we hope that as the milk industry is stabilized and rationalized, this price will be brought down nearer to the level of other countries. A lower price would lead to an increase of consumption. But even at the present high price milk compares favourably with the meats both for Calories and body-building purposes, while as a supplier of calcium and vitamin A it far surpasses them. Skim milk should be procurable instead of being kept off the market.[1] In the summer of 1939 a butter factory received permission from the local Council to pour 1500 gallons of skim milk per day into the sewers. To such criminal folly does the control of the market by producer monopolies lead.

Cheese is a cheap food both for its calcium and vitamin A, its body-building power and calories. It is a notable ingredient of the Oslo breakfast and is used by the Toveruds in a maternity hospital in Oslo for obvious reasons. It would be worth while imitating this practice in this country in feeding the poor.

Butter again is a cheap food, not only for its vitamin A but for its Calories. The middle classes pay as an average 9*d.* per 1000 Calories for their food; the subsistence figure is about 4*d.* per 1000; the British Medical Association figure was 4*d.* per 1000 in March 1940; in Leicester in February 1944 it was approximately 6*d.*; butter at the price of 1*s.* 7*d.* per lb. yields Calories at the rate of 5½*d.* per 1000. A vitaminized margarine at 9*d.* per lb. produces 1000 Calories at 2·6*d.*

Eggs are always unfortunately rather dear, whether for calcium, phosphorus, iron, vitamins A, B_1, the B_2 complex, and D, for the body-building ration or for Calories. They cost 1*s.* 6*d.* for 37 grammes protein and 3*s.* for 1000 Calories at a price of 3*s.* dozen.

As the special salad vegetables and the special fruits are used because of their vitamin C, they must be considered mainly on the cost of that "nutrient." The cheapest way of obtaining this vitamin is from raw cabbage salad, which, however, is not popular in this country. For general purposes tomatoes, lemons, and oranges are the cheapest ways of buying vitamin C, and the sooner we can regain the level of importation of citrus fruits of 1938–9 the better for the nation. As the cost of vitamin C varies with the seasons, the conscientious caterer must calculate from the tables and costs of foods the cost of a ration (30 milligrammes) of ascorbic acid.

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[1] As a war-time measure it is available as Household Milk.

When strawberries are a shilling a pound it may be more economical to buy vitamin C as that fruit rather than as tomatoes or oranges. The trouble is that few people are satisfied with the ounce or so of strawberries which give the day's ration!

The fat fish, with the exception of salmon and sardines, are among the cheapest foods we have for protective purposes (calcium, phosphorus, iodine, vitamins A and D), and for body-building material. For Calories they are medium in price, but cheaper considerably than meat. At the controlled price of 7*d.* per lb. herrings are a cheap food which no one except the rich can afford to omit from his food purchases.

Speaking generally, it is fair to say that the protective foods are not the dearest foods which we buy, and the explanation usually given of their very general deficit in the diet of Great Britain—their costliness—is unfounded. The real reason is habit, tradition, and lack of an appreciation of dietetics.

Second. Economy in first-class protein is best obtained by the use of cheddar style cheese, herrings, and herring roes. At the respective prices of 1*s.* 1*d.*, 7*d*, and 1*s.* per lb. these foods supply a day's ration of first-class protein at 4*d.*, 3*d.*, and 3*d.* respectively. Milk supplies it at 9*d.*, the meats at prices ranging from 6*d.* to 1*s.* and the white fish at a price of from 8¾*d.* (cod at 9*d.* per lb.) to 1*s.* 6*d.* (Dover Sole at 1*s.* 10*d.* per lb.)

Third. Economy in Calories is the easiest thing of all to practise for two reasons: (i) the protective foods and protein foods combined do not often account for more than 30 per cent. of the Calories of the diet; (ii) the range of cost in Calories is enormous. It is one hundredfold, whereas the range of cost for first-class protein rations is only from 3½*d.* to 1*s.* 6*d.*, or fivefold.

There is little point in our setting forth the cost per thousand Calories of all the numerous foods that we eat because prices vary from time to time and place to place. This does not mean that it is impossible in any one town at any one time to give an exact estimate of these costs or of the cost of a reasonable diet. The report of the British Medical Association of 1933 upset that idea for all time. But a set of calculations based on either the West End stores prices in London or the cheap street markets prices would be useless for people living elsewhere, particularly those in the country. Anyone interested in catering economically and dietetically must collect prices and calculate the cost per thousand Calories from them and from the various Food Tables in existence. A general statement which will be true for all parts of the country is the following: "An economical dietary must be based upon cereals and cereal products, the pulses, dried fruit, potatoes, butter, margarine and suet, milk, fat fish, e.g. herrings, sprats, and mackerel, cheese and bacon. Moderate economy only can be found in the meats, while lean fish and eggs are costly and to be considered luxuries. Green vegetables and fruits from the Calorie point of view are also expensive, but as they supply some of the vitamins and the necessary salts, they are essential, and small quantities, despite their Calorie cost, must be included in the diet."[1] For a fuller discussion of economy in diet the reader is referred to the book quoted or to *Sound Catering for Hard Times*.[2]

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[1] Emended from MOTTRAM. (1938), *Food and the Family*. 6th Edn. Nisbet & Co.

[2] MOTTRAM, V. H., and MOTTRAM, E. C. (1932), Nisbet & Co.

PART TWO

THE NATURE OF FOODS

CHAPTER XII

FOODS TAKEN MAINLY FOR ENERGY PURPOSES

In this section of the book an attempt is made to give a survey of the foods eaten by people of European origin, their characteristics and their value in diet. As might be expected, the first difficulty is classification. Shall the foods be classified according to their chemical nature, their biological origin or their function in dietetics ? The problem has given many an organizer of conferences on food a headache. For example, if we follow chemical principles we separate the potato and the turnip, both vegetables ; if biological principles, then marrows, cucumbers and tomatoes are fruits and rhubarb is a "vegetable." Naturally the predilection of the authors is for a functional classification, which again separates the potato from the turnip and leaves meat extracts in something like no-man's-land. It is this functional classification which is adopted, taking the classification [1] of the special joint committee of the combined food board of the United Nations and slightly rearranging some of its items and expanding it somewhat. It is as follows :

Group I.	Oils and fats, including butter and margarine ; sugars and syrups ; cereals ; potatoes ; pulses and nuts.
Group II.	Milk and milk products, excluding butter ; meat, including cured and canned meat and meat extracts, jellies, etc. ; poultry ; fish ; eggs.
Group III.	Fruit and fruit products ; vegetables, leafy ; other vegetables, including many "vegetable" fruits.
Group IV.	Beverages.
Group V.	Condiments.

It will be seen that the first group consists of foods mainly taken for the production of Calories, though butter, cereals and potatoes do supply vitamins as well, and the pulses and nuts supply protein. The second group of foods is taken mainly for body-building purposes, though again all supply vitamins and the milk division mineral elements in addition. Group Three supplies mainly vitamins and inorganic elements—their energy-producing and body-building powers being almost negligible.

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[1] *Food Consumption Levels.* (1944), H.M. Stationery Office.

FOODS TAKEN MAINLY FOR THE PRODUCTION OF ENERGY

1. Oils and Fats, including Butter, Margarine and Cooking Oils

Before the war of 1939–45 it would have been natural to start this section with the cereals and starch- and sugar-containing foods, but it has been brought home to us how much we depend on the tropics and polar regions for our supplies of oil and fat. Probably no deprivation during the war was felt so much as that of fat. At a pinch we can grow half our cereals and sugar in Great Britain and increase our potato crop by 50 per cent. ; but we cannot produce fat at the same time. This comes from tropical or subtropical regions—from palm fruit, palm kernel oil, cotton seed oil and peanuts—or from whale oil, mainly from the Antarctic. The direction in which the dietary of even the poor and unemployed has moved in this country in the last 100 years is in the direction of obtaining more and more fat. Once it was thought that 50 grammes of fat was sufficient per day for the poor. Even in the 1931 slump the unemployed were consuming 100 grammes per day.[1] Nor is this astonishing when it is realized that margarine at 5*d.* lb. produces more Calories per 1*d.* than any other food. Fat per gramme gives two and a half times as many Calories as a starchy or sugary food.

Pride of place among the fat foods is taken by butter. This is more because of the esteem in which it is held by people than because of its intrinsic food value, though it must be admitted that at 1*s.* 7*d.* per lb. it is not a dear food. It costs at that price 5½*d.* per 1000 Calories, and at the price to which it soared in the war of 1914–18 in Great Britain it cost but 8½*d.* per 1000 Calories. Butter-making is, however, not an economic proposition in this country and we shall probably continue to import butter from New Zealand and Australia and sell it here at a price which causes astonishment and indignation in the Antipodes.

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[1] Cathcart and Murray. (1932), *Med. Res. Council. Spec. Rep.*, 165.

Butter

Butter is produced from cream by churning. This causes all the fat globules in the cream to run together into a solid mass, while the fluid part, containing almost all the sugar and most of the caseinogen, remains in the form of butter-milk. The flavour and aroma of butter are due to the growth of organisms in the cream during ripening. The superior flavour of Devonshire and Cornish butter is due to the strains of lactic-acid-producing microbes found in the soured cream used in making butter. These microbes when isolated in pure culture can be used to control the flavour of butter produced elsewhere or even to transfer these flavours to margarine. Acetylmethylcarbinol and diacetyl are two of the substances manufactured by the microbes, for they are found in butter and have an odour reminiscent of butter, but by themselves are not entirely satisfactory in producing a butter flavour.

The trace of caseinogen which remains in the butter is of importance, for the decomposition which it undergoes on keeping is apt to make the butter turn rancid. The presence of water in the butter facilitates this change. Butter will ***keep indefinitely*** if it is dehydrated. This method is largely used in India for the preservation of butter (ghee), and also on the Continent. Commercial processes have been worked out in New Zealand for dehydrating butter for shipment to the forces in World War II, and will probably provide a convenient " spread " in tropical regions after the war. Canada and other countries already put up canned butter for shipment abroad.

The exact ***amount of fat in butter*** varies within limits, but averages about 82 per cent., or twice as much as the amount in cream. An ounce of butter, therefore, may be reckoned as the equivalent of $\frac{4}{5}$ oz. of pure fat. In addition butter contains 12 to 15 per cent. of water and about 2 per cent. of non-fatty organic matter, chiefly caseinogen and milk-sugar. It is rich in vitamin A,[1] but poor in vitamin D.

The most striking chemical characteristic of butter fat is its richness in those fatty acids (butyric, caproic, caprylic, and capric) which are soluble in water. Of these it contains about 7 per cent. Butyric acid, indeed, may be said to be the hall-mark of butter, from which it derives its name. The caprylic and capric acids apparently lower the need for vitamin B_1. Of the insoluble fatty acids present, oleic is the most abundant. Butter fat contains 40 per cent. of olein. This results in a low melting-point (31–34° C.)

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[1] The figure given in *The Nutritive Value of Wartime Foods, q.v.*, is 1136 I.U. per oz., but see above, p. 142.

and that in its turn implies, for reasons we have already discussed, that it is easily digested and absorbed. As a matter of fact, butter is the most easily digested of fatty foods. The fat of the human body has also a large proportion of olein, and melts at an even lower temperature than butter (25° C.). The fact that butter fat approximates so closely to it in its proportion of olein may perhaps help to explain the great value of butter as a food.

The objectionable practice of adding artificial colouring matter to butter has been in vogue for many years. How careful dairies should be in the choice of such colours is seen in the fact that "Butter yellow" produces cancer of the liver in rats.[1]

The ease with which butter is digested renders it of great value as a source of fat in the diet of the sick; patients can take ¼ lb. of it a day without difficulty, and with great advantage to their nutrition. Cooked butter, on the other hand, is much more apt to disagree, probably owing to the liberation of fatty acids in it by the heat employed in cooking. The absorption of butter in the intestine is very complete. Even when ¼ lb. of it is taken per day, less than 0·5 per cent. is wasted. This is a more favourable result than would be obtained with any other form of fat, and should teach us that it may be well to give butter a fair trial before having recourse to medicinal fatty preparations.

MARGARINE[2]

Margarine is a manufactured imitation of butter made by mixing animal or vegetable fats of the right melting-point intimately with soured skimmed milk and rapidly freezing the "mix." To the mixture before freezing some small amount of lecithin is added as a stabilizer and appropriate oil soluble colour to imitate butter. The skimmed milk is very carefully soured with lactic acid producing microbes of a strain selected to give the aroma of butter.

Margarine owes its origin to the ingenuity of the French chemist Mèges-Mouriès, and was first manufactured under his direction for use in the French Navy in the year 1870 and used in the siege of Paris. It was originally made by melting down and clarifying various animal fats, that of the ox being chiefly employed; but at the present day vegetable fats derived from nuts and various seeds and hydrogenated vegetable and whale oils are mainly used in its manufacture. No less than 400,000 tons of oils and fat were used in 1943 in producing the margarine ration.

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[1] ORR and STICKLAND. (1941), *Biochem. Journ.*, 35, 479.

[2] Margarine derives its name from "margarin," a supposed fat, really a mixture of palmitin and stearin. It is also known as "oleomargarine," "butterine," and "Dutch butter," but by the Act of 1887 all butter substitutes are now described as "margarine." In the United States the term "oleomargarine" is employed.

COMPOSITION OF MARGARINE

Water	13·7 per cent.
Protein	0·2 ,,
Fat	85·3 ,,
Calcium, iron and copper	traces
Calories per lb.	3640, or 227 per oz.

Roughly, its crude composition is that of butter and the manufacturers try to keep it so. But it can never imitate butter accurately because milk fat is the only fat with a high content of butyric acid. Coco-butter, the fat from the coco-nut, has a high percentage of the lower molecular weight fatty acids and is used in the better class margarine. But butter can be differentiated from margarines by its high content of volatile fatty acids.[1]

So much from the chemical side. From a physiological point of view margarine is deserving of recommendation. It is absorbed almost as completely as butter, the difference being only about 2 per cent. In other words, 1·02 oz. of margarine are equal in nutritive value to 1·0 oz. of butter. Whatever may once have been the case, margarine is now made only from pure fats, and the processes to which it is subjected in manufacture insure its further purification. As the flavour of the best variety is equal to that of an average specimen of butter—it is indistinguishable in the first 24 hours after manufacture—and as it has the advantage of being very much cheaper, there is every reason to wish that the prejudice against it, which is widespread, should disappear, and that it should be welcomed as an admirable and cheap substitute for a moderately expensive food. In the past it has been objected to margarine that it is deficient in the vitamins which are present in butter. There was some force in this objection, but even before the war margarines were made in which the amounts of vitamin A and D in the substance were raised to the level of a good summer butter. During the war all margarines were, by a gentleman's agreement, vitaminized. In 1944 they contained 550 I.U. vitamin A and 56 I.U. vitamin D per oz. All margarines should be so fortified in the future. Meanwhile it must be said to the credit of the Co-operative Wholesale Society that their margarines were all vitaminized before the war and so too were some made by Unilevers. There are Kosher and vegetarian margarines which contain 200–300 I.U. vitamin A per oz.

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[1] Butter has 7½ per cent. of butyrin; margarine has only 0·25 per cent.

In old-fashioned nurseries children were allowed to have butter or jam with their bread and never the two together. To-day apparently most children get what they like. There was never any real reason for the old rule except that of mortifying the flesh, for butter is an inexpensive source of energy.

At the same time, it must be admitted that one pays for the pleasant flavour of butter. As far as energy value is concerned, a pound of dripping is more than the equal of a pound of butter, and costs only half as much.

We have here another example of the fact, so often pointed out, that in buying foods we pay usually for the likings of the palate rather than for the needs of the body. For those who can afford it, that may be quite justifiable, but for the poor the advantages of margarine and dripping as cheap sources of fat cannot be too strongly insisted upon. The dripping has, however, only small traces of vitamins A and D and on that account, should not be allowed to replace butter and vitaminized margarines in the diet of children.

In addition to butter and margarine there are fats used in cooking or other preparation of food for the table which have been desperately missed during the war of 1939–45. These are *lard* and *bacon fat*, *suet*, *dripping*, *frying fats* and *oil*. Lard is used in pastry-making and in shallow frying ; suet in the making of suet puddings and mince meat ; olive oil for deep fat frying and in salad dressings. They all contain, with the exception of suet, nearly 100 per cent. fat. Thus the analyses are : dripping, 99·0 per cent. fat ; lard, 99·0 per cent. ; and olive and " edible oil," 99·9 per cent. The conventional values of these would be approximately 4220 Calories per lb. or 266 per oz. The figure for suet as given by McCance and Widdowson is also 99·0 per cent. fat, but this must have been for kidney suet, with a very low percentage of connective tissue—it had but 0·9 per cent. of protein and only a trace of water. Older figures by American authorities range from as low as 71 per cent. fat up to 94. It depends on the amount of connective tissue and the source of the suet, subcutaneous, mesenteric or from around the kidneys.[1]

In modern days it has become more and more the custom to buy suet already prepared. Doubtless this will be so after the war, for fewer people will have time to chop suet in the making of puddings and mincemeat. These suets contain up to 16 per cent.

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[1] The Atwater and Bryant figures run from 70·7–94·3 per cent. ; beef suet according to Plimmer has 93·3 per cent. fat, mutton suet 96·6. The Rowett figure is 93·3. Chatfield and Adams for kidney suet give 88·0 per cent. for a thin carcase, 93·0 for a medium, and 94·0 for a fat.

of rice starch to prevent the flakes of suet from running together again. · This, of course, alters the Calorie value markedly. One lb. of 100 per cent. fat should yield approximately 4220 Calories (266 per oz.). 99 per cent. fat yields 4180 Calories (260 per oz.), while a suet of 16 per cent. rice starch, 83 per cent. fat and 1 per cent. water would yield approximately 3800 Calories (237 per oz.). In view of the small amounts of suet in a helping of suet pudding or in a mince tart, this may seem a small point, but it is a point worth making.

There are, too, commercial frying fats and oils on the market. These are hardened or semi-hardened vegetable and animal oils—quite useful commodities and having the same Calorie value as olive oil. Doubtless they will increase in consumption on account of their cheapness when compared with olive oil, but the connoisseur will always look askance at them because of their chemical laboratory odour. It is said, however, that arachis oil (peanut oil) makes a satisfactory substitute for olive oil in salad dressings. The proportion of the Calories obtainable from a salad depends almost entirely on the amount of the oil in the dressing even when potatoes are an ingredient.

We must not overlook the important contribution which fat meats and cheeses make to the Calorie intakes of people although meat and cheese are more reasonably considered among the foods which are taken for their protein content. Fat bacon may have up to 74 per cent. fat with a Calorie value per lb. of approximately 3100 Calories per lb. (193 per oz.). Streaky bacon has 45 per cent. fat with a Calorie value of 2420 (150 per oz.). A mutton chop has 48 per cent. fat and Calorie value of 2140 (133 per oz.). Cheese, such as Cheddar, contains 34·5 per cent. of fat and has a Calorie value per lb. of 1860 (116 per oz.). If nuts formed any large part of the diet they, too, would be important as sources of Calories according to their percentage content of fat.

The amount of fat in food largely determines the amount of the sense of satisfaction we feel at the end of a meal and also of the "lasting effects" of that meal. One reason is that fats are so calorigenous, and that is why in a great war most of us hunger for them.

2. Sugars and Syrups

The importance of sugar as a modern food commodity cannot be over-emphasized. Originally a highly priced condiment it has become with the discovery of cheap ways of production and manufacture so important a source of Calories that dietitians are beginning to ask whether there be not great danger in eating sugar in the quantities we do. The average consumption in the United Kingdom in the years 1935–39 was about 95 lb. per person per year,[1] or 4·17 oz. per day, yielding 467 Calories—i.e. about 15 per cent. of the daily Calorie needs. Consumption in the United States was still higher and reached a peak of 112 lb. per person per year in 1941. Other countries may take much less, the Russians, for example, taking less than a quarter of what we take in Great Britain.

The reasons for the disfavour in which sugar is held are: (i) As usually taken, it is a source of Calories only, and therefore if the appetite be sated on it, foods containing proteins, mineral elements and vitamins are crowded out of the diet. (ii) It is held by American dentists to account for caries of the teeth—an old story neither proved nor disproved as yet. (iii) It may conceivably lead to the development of diabetes. This also has been neither proved nor disproved, but it is possible that the sudden flooding of the blood with glucose throws a strain upon the insulin-producing cells of the islet tissue of the pancreas. Diabetes has increased in the United States somewhat as the consumption of sugar has increased, but this is no proof that the two are causally connected. For the present it is absurd to interdict sugar consumption, but it is wise to be on the watch for possible dangers. The "food reformers" fancy that it is an "unnatural" food to be avoided unless eaten in a raw and unrefined state; we may dismiss this as illogical, unscientific and absurd.

We have spoken as if "sugar," i.e. sucrose or saccharose, the disaccharide occurring in the sugar-cane and the sugar-beet, were the only sugar in question in the diet. So for practical purposes it is, but different varieties of sugar enter into the composition of articles of diet, and they may be divided into two groups: (1) the disaccharides ($C_{12}H_{22}O_{11}$), the chief examples of which are cane, beet, or maple-sugar (sucrose or saccharose), malt-sugar (maltose), and milk-sugar (lactose);[2] (2) the monosaccharides ($C_6H_{12}O_6$) exemplified by grape-sugar (glucose or dextrose), fruit-sugar (fructose or lævulose), and invert sugar, which is a mixture of these two, and is best known in the form of honey.

We may now consider each of these varieties in some detail.

1. **Disaccharides. Cane-sugar** or sucrose, is the most familiar of all kinds of sugar. It is commonly derived from certain special grasses such as the sugar-cane or sorghum, but occurs also in

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[1] *Food Consumption Levels.* (1944), H.M. Stationery Office.

[2] There are other sugars occurring in foods (e.g. trehalose, a disaccharide in edible fungi; raffinose, a trisaccharide from beet molasses; and pentose, a five-carbon sugar in many ripe fruits), but these are of no dietetic importance.

smaller amount in a great many plants and fruits. When derived from other sources than the sugar-cane, special names, such as beet-sugar or maple-sugar, are usually given to it; but it must be distinctly understood that these are chemically indistinguishable from the form of sugar derived from the sugar-cane.

Cane-sugar has been in use in the world as a food for many ages, but it is only within comparatively recent times that it has been manufactured cheaply enough to take an important place in ordinary diets. The following brief history of its introduction into Europe is taken from a pamphlet on *Sugar as Food*, issued by the United States Department of Agriculture: [1]

"Sugar from the sugar-cane was probably known in China 2000 years before it was used in Europe. When merchants began to trade in the Indies it was brought westward with spices and perfumes and other rare and costly merchandise, and it was used for a long time exclusively in the preparation of medicines. An old saying to express the loss of something very essential was, 'Like an apothecary without sugar.' Greek physicians, several centuries before the Christian era, speak of sugar under the name of 'Indian salt.' It was called 'honey made from reeds,' and said to be 'like gum, white and brittle.' But not until the Middle Ages did Europeans have any clear idea of its origin. It was confounded with manna, or was thought to exude from the stem of a plant, where it dried into a kind of gum. When in the fourteenth or fifteenth century the sugar-cane from India was cultivated in Northern Africa, the use of sugar greatly increased, and as its culture was extended to the newly-discovered Canary Islands, and later to the West Indies and Brazil, it became a common article of food among the well-to-do. In 1598 Hentzer, a German traveller, ascribed Queen Elizabeth's blackness of teeth to her great use of sugar. By many the new food was still regarded with suspicion. It was said to be very heating, to be bad for the lungs, and even to cause apoplexy. Honey was thought to be more wholesome, because more natural than the 'products of forced invention.'"

One of the earliest records of the use of sugar in this country [2] is to be found in the accounts of the Chamberlain of Scotland in the year 1319. Its price at that time was 1*s.* 9½*d.* per pound = £2 11*s.* 6*d.* at the value of money in 1939.

The ***composition of the sugar-cane*** and its juice is about as follows: [3]

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[1] Farmers' Bull. (1913), No. 535.

[2] See BANNISTER's Cantor Lectures, 1890.

[3] WINTON and WINTON. (1939), *Structure and Composition of Foods*, **4**, 15.

COMPOSITION OF SUGAR-CANE AND JUICE.

	Stalks.	Juice.
Water	74·96	85·00
Protein	0·58	0·10
Fat and wax	0·38	nil
Sugars	13·40	13·70
Cellulose Lignin Pentosans	10·04	0·65
Ash	0·64	0·45

In order to separate the sugar, the canes are crushed, and the juice expressed by means of heavy rollers. This juice is then clarified by the addition of lime and heating to 94° C. Other clarifiers are basic aluminium carbonate, silicic acid with calcium silicate and sodium aluminate. The clear fluid is readily separated from scum and mud and is then concentrated by boiling *in vacuo* to a water content of 45 per cent. The crystals which form are centrifuged from the mother liquor. This crude sugar is known as *muscavado* and is shipped to the refineries. It contains from 94 to 98 per cent. of sucrose. At the refineries it is still further clarified and finally decolorized by filtration through bone charcoal. The final product of crystallization is white and is 99·50 per cent. pure sucrose. If loaf-sugar is wanted it is run into moulds. Moulded cube-sugar is made in the form of sticks, and afterwards cut into cubes by machinery. Granulated sugars are made in the centrifuge. Other varieties depend on the mode of crystallization and grinding.

Beet-sugar. Fully two-thirds of the "cane"-sugar commonly used is really derived from the sugar beet. The following account of the growth of the industry is from the pamphlet already mentioned :[1]

"Marggraf, a chemist of Berlin, first discovered in 1747 that beets, with other fleshy roots, contained crystallizable sugar identical with that of the sugar-cane. In 1796 Marggraf's pupil, Achard, erected the first manufactory for beet-sugar, and in 1799 he brought the subject before the French Academy. He manufactured beet-sugar on his farm in Silesia, and presented loaves of refined beet-sugar to Frederick William III of Prussia in 1797 ; but the 2 to 3 per cent. of sugar that could be extracted by the methods then in use was too small for commercial success. A new stimulus was given by the sugar bounties of Napoleon in 1806, and methods were rapidly improved, especially in France. Two great difficulties were still to be met : the percentage of sugar present in the beet was small (6 per cent.), and it was separated with great difficulty from the many non-sugar constituents, some of them acrid and of very unpleasant taste. Science now came to the rescue, and a beet was gradually developed having a larger percentage of sugar and a smaller percentage of the undesirable impurities. Barber says that in 1836 18 tons of beetroot were necessary to produce 1 ton of sugar; in 1850 this quantity was reduced to 13·8, in 1860 to 12·7 tons; and in 1889 to 9·25 tons. From 6 per cent. of sugar, as found by Marggraf, the sugar beet of good quality now contains 15 per cent. and more, 12 per cent. being considered necessary for profitable manufacture."

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[1] U.S. Dept. of Agr. (1913). Farmers' Bull. No. 535.

The sugar is extracted from the beets by rasping them to a pulp, extracting and evaporating *in vacuo*, with subsequent decoloration by means of animal charcoal.

To the ordinary consumer beet-sugar is not distinguishable from that derived from the sugar-cane, and it has already been stated that to the chemist the two are really identical. There is no evidence for the statement sometimes made, that beet-sugar is more injurious to health than genuine cane-sugar.

Maple-sugar is derived from the sugar maple of North America by tapping the bark in early spring and allowing the sap to escape as it flows upward. The sap is evaporated and the sugar allowed to crystallize out while the residue is used as maple-syrup. One maple-tree yields about 4 lb. of sugar in a season.

There is no chemical difference between the sucrose of maple-sugar and that derived from the cane or beet, but it is mixed with ethereal substances and organic acids which give it a peculiar flavour. It is probably on the presence of these that the slightly laxative qualities of maple-sugar depend. As a commercial source of sugar the maple cannot compare with either the cane or the beet, and maple-sugar is now chiefly used as a luxury and for the sake of its agreeable taste.

The average composition of these sugars in their raw state is as follows:

COMPOSITION OF SUGARS

Source.	Water.	Cane-sugar.	Invert Sugars.	Ash.
Sugar-cane . .	0·91	96·68	1·01	0·59
Sugar-beet . .	2·42	89·50	5·47	—
Maple . . .	3·70	86·48	8·76	1·06

After being subjected to the process of refining, sugar is practically a pure chemical substance. There is some demand for the cruder "Barbados" sugar, both for confectionery and for the food faddist.

Some types (e.g. "pieces") have a pleasant flavour, but ferment easily and sometimes include livestock. Raw sugar contains appreciable amounts (0·159 per cent.) of cane fibre, dirt, scale and lime salts.[1]

The study of lactose and maltose are best postponed till we deal with milk and malt.

Certain substances derived from cane-sugar deserve brief mention. When strongly heated, sugar melts into a yellowish liquid, and undergoes some physical alteration, so that on cooling it does not crystallize, but forms a transparent, brittle mass, familiar to everyone as ***barley sugar.*** If heated to a still higher temperature its colour darkens, and it acquires a bitter taste, the product being ***caramel,*** which is so largely used in cooking operations.

Treacle, molasses, and ***golden syrup*** are produced as by-products in the manufacture of crystallized sugar. Their syrupy consistence is in part due to the fact that the other substances which they contain prevent the cane-sugar from crystallizing, and partly also to their being fairly rich in fruit-sugar. The following represents their composition:

	Louisianan[1] Molasses.	Treacle.[2]	Golden Syrup
Cane-sugar	47·85	32·5	33·6
Glucose and fructose	23·08	37·2	47·4[3]
Extractive and colouring matter	—	3·5	1·2
Inorganic substances	7·58	3·4	1·3
Water	18·20	23·4	16·4

One pound of Lyle's Golden Syrup yields 1508 Calories (94 per oz.) and contains 13 oz. of mixed sugars equivalent on digestion to more than 13 oz. of glucose. Treacle is an excellent source of iron and calcium in the diet.

2. **Monosaccharides.** The other great group of sugars is the monosaccharides. The best example of these is ***glucose*** which occurs so abundantly in the grape. When grapes are dried to form raisins, the glucose separates out, and may be recognized in the raisins in the form of little yellowish-white granular masses. Commercial glucose is usually got by boiling starch with acids. It occurs in a syrupy form. When heated it turns brown, and is used in cookery as "sugar colouring." Mixed with egg-albumin, it is largely employed in the preparation of "icing" and "fondants" in confectionery and in the manufacture of bonbons.

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[1] Winton and Winton, *op. cit.*

[2] From earlier edition.

[3] Glucose 24·4 and fructose 23·0 per cent.

Fruit-sugar, or fructose, is found, as its name implies, in most fruits. It is with difficulty crystallizable and is hardly ever met with in an isolated form in dietetics.

Invert sugar is a mixture of glucose and fructose. It can be prepared from cane-sugar by the action of ferments or by simple boiling, but more readily by boiling with acids. This "inversion" of cane-sugar, as it is called, goes on rapidly when cane-sugar is boiled with fruit-juice, the active agent being the acid of the fruit. Thus, a considerable proportion of the cane-sugar used in making jam is converted into invert sugar in the process. It is important to remember that invert sugar does not readily crystallize.

Honey is the most familiar form of invert sugar. It contains about equal parts of glucose and fructose, its flavour being due to the presence of small amounts of volatile substances derived from the flowers. The mean composition of pure honey was found by Browne[1] to be as follows:

COMPOSITION OF HONEY

Moisture	17·70	per cent.
Invert sugar	74·98	,,
Sucrose	1·90	,,
Dextrin	1·51	,,
Ash	0·18	,,

McCance and Widdowson give the composition of English honey as: Protein, 0·4 per cent.; fat, a trace; available carbohydrate, 76·4; no starch or dextrin, and producing 288 Calories per 100 grammes or approximately 1320 Calories per lb. (82 per oz.). Honey in the comb has 4·6 per cent. of wax and its Calorie value is 281 Calories per 100 grammes.

The comb consists of waxy substances, which are probably incapable of digestion.

The basis of ***sweetmeats*** is either cane-sugar or glucose. Sugar-candy is one of the purest. It consists of cane-sugar which has been allowed to crystallize round threads and consists of almost pure sucrose.

Toffee consists of melted sugar and butter in various proportions. The home-made toffee of McCance and Widdowson contains 1 oz. butter to 8 oz. sugar and 5 oz. golden syrup. Its composition is 0·2 per cent. protein, 6·2 fat, 90·8 available carbohydrate and yields practically 400 Calories per 100 grammes or 1820 Calories per lb. (113 per oz.).

Chocolate contains about 45 per cent. of cane-sugar, but no glucose or fructose. The rest of it is composed of cocoa-powder. (For analyses, see pp. 479, 480 and 483.)

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[1] Quoted by WINTON and WINTON, *op. cit.*

A mixture of glucose or invert sugar and cane-sugar is used in the preparation of uncrystallized sweets, such as the creamy matter in the interior of chocolates.

The colouring of sweets is derived either from burnt sugar or from one of the aniline dyes, most commonly eosin. Cochineal is also a favourite colourer. It is interesting to note that aniline dyes may be excreted in the urine almost unchanged, and cases are on record where patients have been supposed to be passing blood, when they had merely been sucking red sweets. There is no reason to suppose, however, that such substances are in any way harmful.

Jams consist essentially of fruit preserved in a strong solution of sugar. We have already seen that the acids of the fruit, aided by the high temperature employed in the course of preparation, bring about the conversion of a considerable proportion of the cane-sugar into the invert form. Home-made jam is usually boiled for a longer time than the commercial article, and consequently contains more invert and less cane-sugar than the latter. Aitchison Robertson [1] gave the proportion of cane-sugar in most home-made jams as 20 per cent., while commercial jams have anything from 10 to 50 per cent. In some home-made jams which he examined the proportion of cane-sugar which had been inverted was as follows:

	Proportion of Cane-sugar inverted.
Strawberry	two-fifths
Raspberry	three-fifths
Blackberry	four-fifths
Marmalade	five-sixths
Plum	six-sevenths

The importance of these figures is derived from the fact that the larger the proportion of cane-sugar which has been inverted, the less likely is the jam to interfere with digestion (see p. 230).

Commercial glucose does not crystallize and so is often used to make jam from inferior fruit or from the remains of fruit, the juice of which has been used to make fruit syrups and jellies. Such jam may have a good appearance, but is deficient in fruit flavour. It is, however, quite wholesome and nutritious.

The "setting" of jellies is due to the presence of pectin in the fruit (p. 21). If boiled too long, the power of gelatinizing is lost, and a syrup results instead of a jelly. In commercial jams and jellies pectin is sometimes added to prevent this. There is a preparation on the market of pectin which is used in making home-made jams set.

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[1] "The Value of Saccharine Foods as Articles of Diet." (1898), *Scottish Medical and Surgical Journal*, **3**, 30.

More than half the weight of any given quantity of jam is made up of sugar in some form or another. The nutritive value of jam resides almost entirely in its sugar content, its Calorie value being 1160 per lb. (72 per oz.).

Digestion of Sugar

The first factor which determines the digestibility of a sugar is its chemical form. No matter in what form sugar is consumed in the food, it can only be assimilated as a monosaccharide (glucose, fructose or galactose). Hence we find that provision is made in the alimentary canal for the conversion, by means of suitable ferments, of all forms of disaccharides into glucose, fructose and galactose ; i.e. they are hydrolysed. It is evident, then, that from a dietetic point of view we may speak of the disaccharides as undigested and the monosaccharides as predigested sugars. It now becomes clear why sweet fruits are such important dietetic sources of sugar. It is because they contain the latter in a form in which it is fit for direct absorption into the blood. For the same reason honey must be regarded as a very easily digested saccharine substance, and the importance of the inversion which cane-sugar undergoes in the manufacture of jams also becomes manifest. The superiority of home-made over commercial jams is also set in a clearer light by reference to these considerations.

The second factor which influences the digestibility of a sugar is the degree of concentration of its solution. In strong solution sugar is an irritant to the tissues. In contact with the skin, it is apt to set up superficial inflammation. This is familiar in the form of the eczema which is apt to appear in diabetics from the contact of the sugar-containing urine with the skin, and from the similar condition occurring on the arms of grocers and other persons who have frequently to handle sugar, and it is on account of its irritating properties that sugar cannot be used as a subcutaneous aliment, though otherwise well adapted to fulfil that function. All attempts to use it in that fashion have been frustrated by the pain which it sets up. The same is true of the stomach. Brandl, experimenting on dogs, found that a 5·7 per cent. solution of sugar produced reddening of the mucous membrane ; if the concentration was increased to 10 per cent., the mucous membrane became dark red, while a 20 per cent. solution produced pain and great distress. This irritating effect on the mucous membrane is accompanied by the production of much mucus and the pouring out of a highly acid gastric juice. Enemata must not contain more than 4 to 5 per cent. of glucose. These irritating effects seem to be much more pronounced in the case of cane-sugar than in that of the hexoses.

As used in ordinary diet cane-sugar depresses the acidity of the gastric juice and delays evacuation of the stomach.[1] A hyperchlorhydric person can take sweets between meals with impunity but a hypochlorhydric cannot. It would be interesting to discover whether the sugar added to the fruit or the cereal course at breakfast delays evacuation of the stomach or not. When sucrose enters the duodenum it is so rapidly inverted and absorbed that for administration by mouth for therapeutic purposes glucose has few advantages over ordinary cane-sugar.[2]

But all disaccharides must be digested to monosaccharides before they can be of use to the body. Lactose and cane-sugar, if they get into the bloodstream, are excreted quantitatively by the kidneys unchanged. Nor can the body deal with pentoses if they enter the system. They too are excreted unchanged and a pentosuria results from the free consumption of fruits.

The last point connected with the influence of sugar on the digestive organs is its supposed ***injurious effects on the teeth.*** The impression that sugar-eating is bad for the teeth is so widespread that one can hardly suppose it to be devoid of all real basis. It must be admitted, however, that the supposition is not supported by any very conclusive observations. If sugar does destroy the teeth, it probably does so indirectly by lingering in the crevices of the mouth, and leading to the production of acids which eat away the enamel, though, as far as we know, no one has yet proved that *B. acidophilus* can produce a sufficiently high hydrogen ion concentration to attack the enamel.[3]

Assimilation of Sugars

The fate of sugar after entering the blood is to be converted into glycogen and stored by the liver and muscles as glycogen. Now, it has been found by the physiological experiment of injection into the bloodstream that not all sugars are capable of being directly converted into glycogen.

It is considered that fructose is directly converted in the liver but that glucose passes to the muscles first and is converted there. As the kidney threshold value is lower for fructose than glucose, the sugar tolerance for fructose is less than that of glucose. Most people secrete fructose in the urine if they take more than 50 grammes on an empty stomach. The tolerance for glucose is much higher, and 100 or, in exceptional circumstances, 200 grammes can be taken on an empty stomach without causing glycosuria.

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[1] MILLER, BERGEIM, REHFUSS, and HAWK. (1920), *Amer. Journ. Physiol.*, 53, 65.

[2] *Lancet.* (1935), 1, 444.

[3] See W. H. S. WALLACE. "The Place of Sugar in the National Diet." (1935), *Public Health.* Dec., 84–9.

It must further be borne in mind that the assimilation limit is not the same for all individuals. Some people are better able to convert sugar into glycogen or have a higher threshold than others, and most people can take 50–100 or 200 grammes of glucose without passing sugar in the urine. If glycosuria occurs it is either due to the blood sugar being raised above the normal limits (i.e. the patient has diabetes mellitus, which may be mild or severe) or the threshold of the kidney is lowered and glycosuria occurs although the blood sugar is within normal limits.

Notwithstanding all this, it must be noted that, if sugar is taken along with other food, and distributed uniformly over the day, very large quantities can be consumed without the danger of exceeding the assimilation limit. Vaughan Harley was able to take a pound of cane-sugar daily—with injurious results as regards his digestion, it is true, but without producing glycosuria. As a general rule, one may assume that 4 oz. can be taken daily without any bad results, but the exact amount must of necessity depend to a large extent on the muscular activity of the subject.

Nutritive Value and Economy of Sugar

We have seen that refined sugar is to be regarded as a practically pure carbohydrate. That being so, its food value must be high, for every gramme of it will yield 3·95 Calories of energy.[1] An ordinary lump of loaf-sugar weighs about 5 grammes, and yields therefore nearly 20 Calories. Five such lumps contain as much carbohydrate as a 5 oz. potato. It is evident from these considerations that even the amount of sugar ordinarily added to a cup of tea may contribute in no small degree to the supply of energy required by the body daily. A pound of butter will yield about twice as much energy as a similar weight of sugar, but at nearly four times the cost, for sugar is one of the cheapest fuel foods. Even at 4½*d.* per lb. it produces Calories at 2½*d.* per 1000 or about the same cost as bread.

It is ***as a muscle food,*** however, that sugar is of special importance. We have already learnt that the carbohydrates are probably the chief source of muscular energy, and the sugars, on account of the ease and rapidity of their absorption, are better calculated to fulfil this function than any other member of the carbohydrate group. For mention of its use in training, see p. 259 and, for early evidence of its value, previous editions of this work. It is extremely useful also in rapidly raising the level of "sugar" in the blood when for any reason, e.g. fasting, severe fatigue or an overdose of insulin, it has fallen to a low point.

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[1] It has been calculated that a single caramel or a pennyworth of "candy" yields sufficient Calories to provide the extra energy required in walking a mile (see C. G. and F. G. Benedict, "The Energy Content of Extra Foods," (1919), *Boston Med. and Surg. Journ.*, October 2, 415).

3. Cereals

Man, like every other animal, has always had to "live off the land," using the term in Stefánsson's sense to include water and air. That is, he has to convert their products to his own purposes in providing food. In this he has gone through three stages.

First, he has hunted and lived on the products of his bow, spear and fishing line—a most precarious way of living, still practised by races in a land where settled agriculture is impossible. It produces a diet consisting mainly of protein and fat with very little carbohydrate. The Eskimos are perhaps the best example to-day of such early methods of "living off the land." No land, so exploited, can sustain a dense population. The method is uneconomical and unplanned.

The second stage is the nomadic, in which man has domesticated some animals and looked to an ordered control of their fertility for a supply of meat and milk. This method obtained in early biblical times and to-day the Masai are a good example of survival of this mode of "living off the land." It too produced a diet consisting mainly of protein and fat but with rather more carbohydrate.

The third stage is a stable agriculture, based upon the cultivation of cereals, wind-pollinated grasses, mainly, which grow in close association one with another and can be easily brought under control. This type of agriculture produces a diet which is mainly carbohydrate with much less fat and protein. It ties, too, the agriculturist to the soil. Nomadic life becomes impossible. Such agriculture, beginning in the alluvial soil along the river valleys of Mesopotamia and Egypt, many thousands of years ago, has now spread to every tropical, subtropical and temperate land, and cereals can now actually be raised within the Arctic Circle. The type of cereal is naturally not everywhere the same. It is wheat in the drier subtropical and temperate lands of Europe, North America, the Argentine, Australia, and India. In more humid and hotter parts of the world it is rice; and where, as in northern Germany, northern Russia and Scandinavia, wheat does not ripen well, rye takes its place. The same is true of Scotland, but there oats take the place of rye, though at one time rye was very commonly grown in Great Britain. A new cereal, maize, invaded the Old World from the New, and has thoroughly established itself round the Mediterranean, in Roumania and Egypt and in South Africa. Barley is a crop which can be grown on poor soils and as it ripens early, it once was a staple cereal in human diet in the northern parts of England. It is to-day used more for fodder and the manufacture of malt. Millet and buckwheat, though not strictly cereals, have a similar mode of cultivation and millet forms the staple diet in parts of Africa and China.

The success of cereal agriculture is due to the fact that land can produce about five times as much "food" as when given over to dairy produce. More bulk of food is available and a greater density of population assured. Moreover the population, though dense, is tied to the soil. Civilization, as we understand it, depends upon density of population and tradition. Without cereals, density of population is impossible. The handing down of tradition is easier in a static population than in a nomadic. There can be no real civilization apart from cereal agriculture.[1]

Now cereals by themselves are poor foods, especially for human beings with alimentary tracts which cannot cope with bran and with phytates. Their proteins are not so valuable in human nutrition as those of milk, eggs, cheese, fish and meat. They have less lysine, methionine and tryptophane in their constitution and much more glutamic acid; moreover, often the percentage of protein is low in cereals especially when cooked, as cooked they must be. Their content of calcium is low, their ratio of calcium to phosphorus very low, what calcium there is is unavailable, their iron, though high, is also unavailable to man. It is true that their content of vitamin B_1, thiamine, is high, and they have moderate quantities of nicotinic acid and riboflavine, but, with the exception of vitamin E, they have but negligible quantities of the other vitamins.

They are therefore poor foods and wherever they form a high percentage of the diet—say over 60 per cent.—the growth of their eaters is stunted and the physique poor. They make for faulty bones and teeth, for anæmia and avitaminoses A, C and D. This fact cannot be over-emphasized: the value of cereals in diet is that they are a *cheap source of Calories.* It is almost their only value.

Wheat is the aristocrat among the cereals both for dietetic and technical reasons and where *other* cereals form the staple food of the diet it would be well to displace them by wheat. On the other hand, the reduction of the consumption of wheat in this country by about 13 per cent. in the years 1900 to 1939 and its replacement by foods such as milk, cheese and so forth is to be welcomed by the dietitian. Naturally, during the war of 1939–45, there has been a great increase in Great Britain's consumption of wheat and other cereal products—about 20 per cent. at the maximum—and it is to be hoped that in the years to come this will be diminished.

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[1] The ancient civilization of Peru seems to have been based on the potato.

WHEAT

If a grain of wheat is cut into thin sections and examined under a microscope, it will be found to consist of the following parts (Fig. 13):

1. The ***germ,*** or embryo. This is simply the young plant. It represents about 1½ per cent. of the whole grain.

2. The kernel, or ***endosperm.*** This consists of two large masses of nutritive material for the use of the embryo. It makes up 85 per cent. of the grain.

3. The ***bran***—an outer envelope mainly composed of " cellulose " impregnated with mineral matter, and designed as a protective covering to the grain, of which it makes up about 13½ per cent.

4. The ***scutellum***—a membranous tissue between the germ and the endosperm, interesting in that it contains a large amount of vitamin B_1 (thiamine).

The chemical composition of the whole grain and of its three components is shown in the table on page 303, constructed from *The Nutritive Values of War-time Foods.* It will be noticed that the germ is characterized by its richness in protein and fat, the endosperm by an abundance of starch, and the bran by a preponderance of mineral elements and cellulose. It should be added that the germ is further peculiar in that both its protein and its carbohydrates are chiefly present in a soluble form, and it has a high amount of vitamin B_1 (thiamine).

If the section of wheat is more highly magnified, the structure of its various components can be made out in greater detail. One can then see (Fig. 14) that the ***endosperm*** consists of a delicate honeycomb of cellulose, the cavities of which are full of starch grains, the interstices being filled up by smaller particles consisting of a protein or mixture of proteins called gluten. The gluten granules are most abundant in the outer zones of the endosperm.

The relative proportions of starch and gluten differ in different kinds of wheat. Generally speaking, it may be said that those

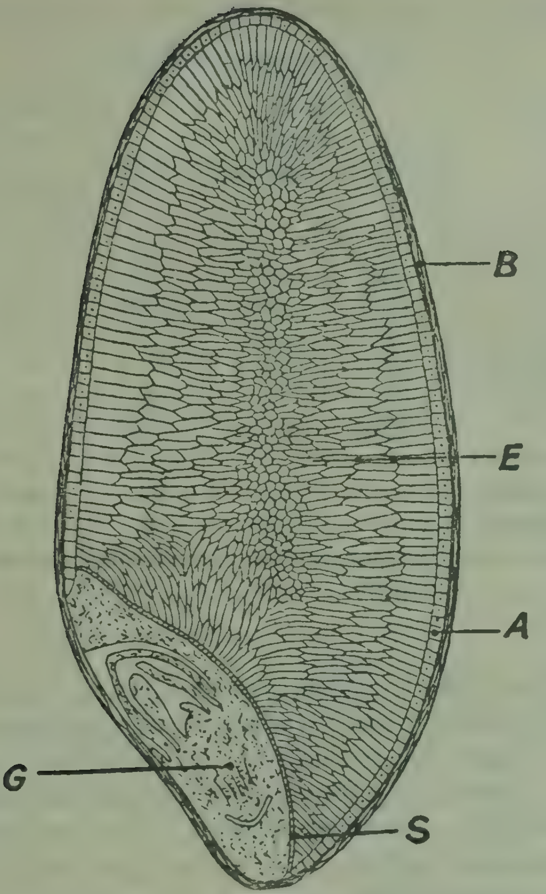

FIG. 13.—DIAGRAM OF LONGITUDINAL SECTION THROUGH A GRAIN OF WHEAT.

A. Aleurone layer of cells forming outermost layer of the endosperm.
B. Pericarp, forming the branny envelope.
E. Parenchymatous cells of the endosperm.
G. Embryo or germ.
S. Scutellum.

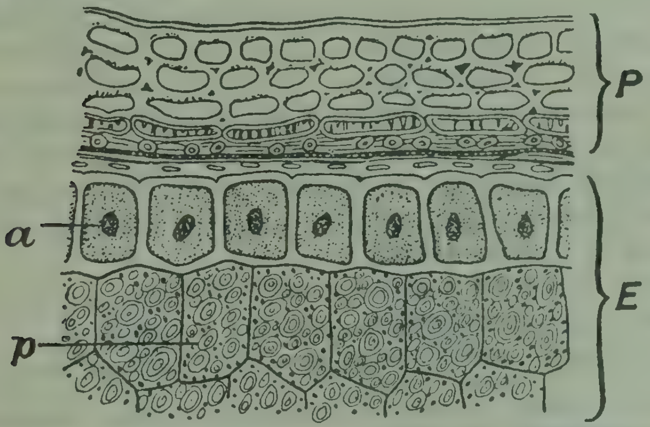

FIG. 14.—CROSS-SECTION THROUGH THE BRANNY ENVELOPE AND THE OUTER PORTION OF THE ENDOSPERM.

P. Pericarp or bran.
E. Endosperm consisting of *a*, layer of aleurone cells, *p*, parenchymatous cells.

COMPOSITION OF THE DIFFERENT PARTS OF A WHEAT GRAIN
(100 grammes contain)

	Bran.	Endosperm.	Germ.	Whole Grain.	
				English.	Manitoba.
Water (g.) . .	8	13	8	13	13
Protein (g.) . .	10·9	13·1	32·0	9·1	13·9
Fat (g.) . . .	4·2	1·2	7·7	2·3	2·6
Carbohydrate (g.)	54·5	71·6	37·8	68·1	64·3
Calcium (mg.) .	98	13	58	36	28
Iron (mg.) . .	12·9	1·8	9·7	3·1	3·9
Vitamin A (I.U.)	0	0	—	0	0
„ B_1 (μg.)	—	69	2100	294	363
„ C (mg.).	0	0	0	0	0
The figures for cellulose, taken from an earlier edition of this book, are					
	18·0	0·7	1·8	5·7	1·7

grains which look hard, translucent, and horny on section, are rich in gluten and poor in starch ; while for the grains which are soft, opaque, and floury on section, the reverse holds good.

The ***bran*** (pericarp) is found to consist of two distinct layers:

1. An outer layer consisting entirely of fibres of cellulose impregnated with mineral matter. This is the layer which is removed in the decortication of wheat.

2. An inner layer consisting chiefly of small cells full of pigment, which give to the bran its brown colour. This layer is much poorer in cellulose than the first.

The outermost layer (the ***Aleurone Layer***) of the endosperm consists of a single row of large cells containing a fine network of protein matter enclosing small globules. It contains least cellulose of all, and is removed with the bran. This layer has always intrigued dietitians and claims are made for its importance because it contains proteins of high biological value usually lost with the bran. The scutellum had been overlooked until 1944 when Hinton [1] showed that it contained on the average 59 per cent. of the total thiamine of the whole wheat.

The ***germ*** consists of a mass of small cells rich in protein and fat, but its more minute structure does not concern us.

The wheat grain may be used as a food in its entirety. Soaked in water till it swelled up and burst, and then boiled in milk, with the addition of sugar and other ingredients, it formed the old and very nourishing dish called ***frumenty,*** which is now, however, but seldom seen on the table and is very difficult to masticate.

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[1] HINTON. (1944), *Biochem. Journ.*, **38**, 214 ; WARD. (1943), *Chem. and Industry*, **62**, 11.

Far more commonly it is reduced before eating to a state of meal or flour by the process of ***grinding or milling.*** Now, it is an exceedingly difficult matter, owing to its toughness, to reduce the bran of wheat to a powder by grinding. It can be done, but the trouble and expense entailed are great. Graham [1] bread is made from whole wheat flour in which the bran has been finely triturated. As the bran in normal whole wheat is coarse, unpleasant to eat and irritating to many alimentary tracts, attempts have been made from earliest times to separate the bran from the rest of the flour.

From Norman times until the forties of last century the usual mode of grinding corn was between mill-stones made from millstone grit. The lower horizontal stone was stationary, the upper revolved. The cleaned wheat was fed through the axle of the upper stone and passed between the two stones out towards the circumference, being cracked, broken and ground to powder in the process. This cracking, breaking and grinding was facilitated by grooves cut in the stones and this grooving had to be renewed frequently. The dust thus worn off the stones mingled with the flour. The resulting flour was " 100 per cent. whole meal " and is still the aim of those who maintain that man should eat whole food as presented to him by Nature. It contains coarse bran, finer bran, endosperm, stone dust and germ mixed together.

Such wholemeal flour produces a bread which is unpalatable to many and upsetting to many alimentary tracts. From Norman times it has been the custom to sieve off the bran by means of bolting cloth, originally made from wool or linen, but to-day made from silk. By consent, flour from which the coarsest bran particles are removed, consisting of about 92 per cent. of the original wheat, is called " wholemeal," though, of course, it is nothing of the sort. Further bolting removes the finer bran, and in the end a flour passably white is obtained. It represents about 75–80 per cent. of the grain. What is removed is the fine and coarse bran; what remains is the endosperm and some, if not all, of the germ. Such a flour is known as standard stoneground flour and was, until the war of 1939–45, obtainable by those who preferred that sort of flour.

The Norman baron and his wife preferred white flour, and the bread made from it, to the coarser bread made either from unbolted flour or the mixture of rye and wheaten flour which was the lot of the serfs. The city merchants naturally imitated the aristocracy to the intense indignation of the latter, and preferred white bread to " black " or " brown." As naturally, to eat white bread became the mark of aristocracy and plutocracy, and brown bread the badge of poverty. Some remnant of this survives to this day. At any rate whiteness of flour became desirable and milling evolved in the direction of producing a whiter and whiter flour.

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[1] Sylvester Graham was an American vegetarian. *Floruit* 1840. His name is still honoured in Germany; DRUMMOND and WILBRAHAM. (1939), *The Englishman's Food.*

In the eighteen-forties a new method of milling was begun—crushing between rollers rather than between stones. This was named the roller process. It won its way first in Austria-Hungary, milling the hard Hungarian wheat, and it gave Vienna its well-known supremacy in bread- and pastry-making. It did not make its way into Great Britain till about 1880, for there was difficulty with the rollers and with the type of wheat. Roller milling succeeds best with the hard wheat such as we now obtain from Manitoba and not with the soft English wheats. Roller milling has now practically replaced stone grinding, and, for reasons that appear by no means scientific, has received the execration of most dietitians.

The Roller Process. The wheat, after having been separated from " foreign bodies " such as nails, nuts, coin, wire, paper, shrivelled grain, maize, oats, corn cockle seed and other seeds, is washed, dried and sucked to the top of the mill. Thence it is fed by gravity between parallel horizontal hard steel rollers about 6 ft. long. The distance apart of these rollers can be adjusted to one-thousandth of an inch. Both rollers have spiral grooves cut in them, but the pitch of the upper spiral differs from that of the lower. The grain passes between the rollers and in doing so is caught by the spiral grooves and cracked or broken. This is called the " first break." Some bran is cracked away from the endosperm and germ, some of the endosperm is cracked and broken as well. The resulting mixture then passes between two parallel smooth rollers which continues the process, some flour—i.e. ground endosperm—being produced at this stage. The bran is blown off, the flour sieved off, and the remainder consisting of broken grain, semolina and germ passes to the top of the mill again. The flour produced at this first break is a darkish flour—in milling parlance it has no colour, for colour means " white."

The unground part of the mixture is ready for the second break. It passes between grooved rollers again, but the rollers are closer together, the grooves shallower and the pitch of the spirals not so great. Again the grain is further cracked, bran sheared off and flour produced, for after the break the resultant mixture passes between smooth rollers set closer together than the first pair. The flour sieved off at this stage—second break flour—is, with the third break flour, the whitest there is.

It is usual in the best mills in Great Britain to have four breaks only, but American and Canadian mills have pushed the breaks still further to get off the last remnant of endosperm from the bran.

The germ sticks to the third pair of smooth rollers and, being scraped off them, is collected as a separate fraction. In fact roller milling is an elaborate, semi-automatic, cheap and efficient way of fractionating wheat into its constituent parts and represents an advance on the cumbrous method of stone grinding. If an attack is to be made, it is not on the process itself, but on the use the millers and public have made of the process. If we want the germ, for making germ bread or Bemax, we have it. If we want pastry whites then we take the second and third break flour representing about 40 per cent. of the wheat seed. If " straight run " flour, we add the four breaks together. So called " whole meal " can be synthesized by adding to straight run flour the fine bran and the germ. The roller process has given us much more control over what we get from wheat and what we make from it—we have to see that we make the right things.[1]

There are further practical advantages in this " fractionation." The white flour keeps better than the stoneground white flour. Some of the germ possibly and the oil and diastatic ferments of the germ are present in the stoneground flour. The oil oxidizes and goes rancid and the flavour of the flour depreciates. The germ produced by the roller mills can have its ferments destroyed by cooking with superheated steam and then be ground to a fine meal for the manufacture of germ breads (Smith's patent). " Hovis " flour consisted till the war of 1939–45 of one part wheat germ meal to three parts of ordinary flour. It therefore contained more protein, more fat, more vitamins of the B complex than ordinary or even than wholemeal flour and produces a bread more flavoursome than white without many of the disadvantages of bread made from wholemeal flour.

Then, too, the bran separated from the flour forms food for domestic animals which possess alimentary tracts competent to deal with it, e.g. the horse, cow, pig and hen and it is a debatable

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[1] Any chemist would prefer straight phenol and the rest to crude tar, and a technician octane, petrol, medicinal paraffin, lubricating oil and paraffin wax, to crude oil.

(and debated)[1] problem whether it pays us better to feed the offals to the cow and the hen and get a return in first-class protein or to eat the bran ourselves at first hand. In time of war it has always appeared reasonable to increase the amount of bran in the flour for making pastry and bread. If we ourselves eat a greater percentage of the wheat kernel we do not need to transport so much wheat. In the Napoleonic wars it was so and in the two World Wars. Some countries—Eire and South Africa—went as far as 100 per cent. extraction. We compromised at 85 per cent. extraction with a small dilution with home-grown barley meal, oatmeal and rye at the time of greatest urgency. But as soon as possible we got rid of the additions and in 1944 began to reduce the percentage extraction towards the 72 per cent. level again. By 1945 it reached the 80 per cent. level and the Minister of Food proclaimed it as " nutritious " as the 85 per cent. extraction flour,[2] while many people interested in nutrition consider this a grave error of judgment.

This is clearly the place to attempt an objective account of the hundred-year-old controversy of white versus wholemeal, with the warning that so many factors of prejudice are involved—conservatism, gastronomy, bowel consciousness, vested interests and politics—that scientific principles, even among the scientists themselves, disappear into a fog of unproved assertions.

The main uses of flour are in the production of bread, pastry and other confectionery and biscuits. For the last, English wheat flour is preferred with its low protein content, while for bread and confectionery, a flour with more rising power is desired. The proteins of wheat, gliadin and glutelin, when mixed with water, form an elastic paste which can be stretched considerably without breaking. Flour containing much gluten can be blown up into a sponge by forming carbon dioxide within it. This can be brought about either by the use of yeast, by baking powder or by actual " aeration " with carbon dioxide under pressure. A sponge so blown up, on baking " sets," i.e. the gluten is coagulated and the form of the blown out sponge retained. The bread, cake or pastry so made is " light " in comparison with similar products made from the other cereal flours. Rice flour and oatmeal will not make bread. Rye flour by itself makes a badly risen soggy bread and is usually mixed with wheaten flour in making the bread eaten on the continent of Europe and by immigrants from mid-Europe into this country and doubtless into the United States. Barley meal also has to be mixed with wheat flour to produce a bread or pastry. Wheats differ from one another in their capacity to form a sponge. The " soft " wheats of Great Britain have a lower gluten content than the " hard " Hungarian or the Manitoba wheats. The bread made from them does not rise as well as that from the harder wheats and Vienna owes its pre-eminence in confectionery to them. The name " Vienna " has passed into currency for the lightest bread made in this country, though it is not made with Hungarian wheat flour. But it is not only the amount of gluten which determines the power to form a good " sponge." Other factors, such as the presence of other proteins than gliadin and glutelin, of bran and of different amounts of mineral elements also affect that power.

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[1] See WRIGHT. (1941), *Chem. and Ind.*, **60**, 623; BACHARACH. (1941), *Chem. and Ind.*, **60**, 791.

[2] In the sense in which dietitians use the word nutritious this is not true, for if we wish to retain the maximal amount of the nutrients 85 per cent. extraction should be maintained.

There is everywhere a movement towards standardization of manufactured food products. The purchaser prefers a bread, a beer or a butter which always looks the same, tastes the same and has the same texture. Consequently millers and bakers prefer a white flour, not only because it has better keeping qualities under prevailing conditions, but because it bakes bread and other commodities of a more standardized quality. The public, rightly or wrongly, likes white bread because of its whiteness, which they confuse with purity, because of its texture in eating and possibly because of a traditional belief that to eat brown bread is a mark of social inferiority. As Renner points out, the gastronome dislikes the variation in texture produced by bran in the bread and by the crust, so that he removes the crust from toast and sandwiches.[1] The millers and bakers are out to give the public what it wants without consideration of dietetic values and so take the utmost trouble to standardize the flours they produce. They dislike English wheat flour with its low rising power, its high water content and its variability and before the second World War resented the compulsion to use 20 per cent. of home-grown wheat. They preferred Canadian, Argentinian and Australian wheat because they could blend them to produce a standardized flour which gave (i) more loaves to the sack, and (ii) more standardized bread, etc. Flours with germ proteins in them, varying quantities of mineral elements, diastatic ferments and so on need varying amounts of yeast in the making of bread, and baking powder and eggs in the manufacture of confectionery.

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[1] RENNER. (1944), *The Origin of Food Habits*, 41. The odd thing is that toast crusts by themselves are a pleasant form of food, but attached to the toast they are an offence, a thing which any gastronome may prove for himself. An anomaly is that he likes ice-cream made with brown bread crumbs as an ingredient.

The change-over from the stoneground flours mainly of English origin to roller-ground flours mainly of foreign origin has been an inevitable process. Nor was that change-over in the nature of the flour quite so rapid as has been claimed by the opponents of the roller process. Great Britain did not suddenly change to a " devitalized " flour with the introduction of the roller process. Thus in 1786–91, Wyatt of the Albion Mill, claims that the 55 per cent. extraction flour was used in the white bread in general consumption in London.[1] The degringolade from high extraction to low extraction flour was well under way a hundred years before the introduction of the roller process into Great Britain.

But though the change-over was almost inevitable, it does not follow that dietetically it was sound. The arguments for and against the use of white flour are set out below, but the reader must bear in mind—a thing too readily forgotten—that both white flour and wholemeal flour *by themselves*, or made into bread, are bad foods.

Wholemeal, whether 100 per cent. or the usual 92 per cent. extraction contains more protein and protein of a higher biological value, more B_1 (thiamine), riboflavine, nicotinic acid, calcium, phosphorus, iron and roughage than white flour. Therefore, say the upholders of wholemeal flour, it is better for us. All the statements in the first sentence of this paragraph are true, and it appears at first sight that the case against white flour is complete.

The figures given by the Medical Research Council [2] are as follows:

	Protein. g.	Calcium. mg.	Iron. mg.	Vitamin B_1 μg.	
100 per cent. extraction English flour	9·1	36	3·1	294	per 100 grammes
70 per cent. extraction English flour	8·1	19	1·4	87	
100 per cent. extraction Manitoba flour	13·9	28	3·9	363	
70 per cent. extraction Manitoba flour	13·1	13	1·8	69	

For riboflavine and nicotinic acid the differences though great are not so pronounced but the fibre (roughage) may be as low as

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[1] RICH. (1941), *Chem. and Ind.*, **60**, 611. Rich also states that the belief that much of the germ passes into the 75 per cent. extraction flour produced by stone grinding is untrue.

[2] *Nutritive Values of War-Time Foods.* (1945.)

0·2 per cent. in white flour and as high as 2·6 in 100 per cent. whole meal.

But except for vitamins of the B class the case is by no means so complete as the above figures seem to show. Percentage composition by no means spells availability. Because wholemeal contains more protein, more calcium and more iron it does not follow that the body absorbs more of them. In fact, from the early work to the present day, experiments comparing the absorbability of the constituents of foods with much roughage with that of foods with little, have shown that though the rough foods may have more of the proximal nutrient materials, the effect of the peristalsis the roughage produces in the human gut is that the body often picks up less. This has been investigated for bread, for rye bread and for rice, among other foods, and the results all point in the same direction.

For example: Macrae[1] and colleagues investigated the energy, protein and fibre "digestibility" of white bread from 73 per cent. extraction flour, and of wholemeal bread from 100 per cent. extraction flour of two degrees of fineness of milling. They found that 96·1 per cent. of the energy value, 91 per cent. of the nitrogenous substances and 65·8 per cent. of the fibre of white bread were wholly absorbable, whereas the figures for fine wholemeal bread were 86·9, 85·3 and 14 per cent. and of the coarser wholemeal bread 87·1, 85·7 and 9·7 per cent. respectively. As regards energy value—and we consider that the chief reason for eating cereal products is their energy value—the lower extraction flour wins. Taking the energy values of white and wholemeal bread as approximately equal, the body obtains 5 per cent. more Calories from a pound of white bread than from a pound of wholemeal. Of course this means but 50 Calories all told, which is, it is true, very little to boast about, and it may be purchased at too great a cost. Turning to the protein intake by the mouth, we find that though the wholemeal bread furnishes 2·91 grammes of nitrogen, say 18 grammes of protein, per 100 grammes, the white bread furnishes but 2·7 (say 16·7 protein). This, however, is offset by the larger amount of nitrogen lost in the fæces when on wholemeal bread. The net absorption is almost the same, viz. 14·8 and 15·2, the difference being of the same order as the error of the experiment.[2]

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[1] MACRAE, BACON, HUTCHINSON and McDOUGALL. (1941), *Chem. and Ind.*, 60, 723.

[2] It must be admitted that the analyses of bread vary within somewhat wide ranges. If we applied Macrae's results to bread showing the analyses given by McCance and Widdowson, we should find the argument in favour of wholemeal (92 per cent. extraction). Such an application would, however, not be reasonable.

So far the results lead us to prefer neither white nor wholemeal flour to the other, but there is the question of the biological value of the proteins. Unfortunately this has never to our knowledge been measured for man but only for the laboratory rat. Chick and Work[1] showed that though the availability to the rat of 75 per cent. extraction flour, national wheatmeal flour and wholemeal flour was 89, 86 and 84 per cent. respectively, the young rat grew faster by some 30 per cent. on the wholemeal than on the white flour, when it formed the only source of protein in their diet; national wheatmeal giving an intermediate value. Such observations have great value. But it may be pointed out that to apply rat-feeding experiments directly to man is not wise. Even in the lowest stratum of human society in this country man does not live on bread alone. Indeed the governmental policy during the second World War has been to supply the rapidly growing young with a cheapened source of protein of high biological value in milk, the effects of which swamp the small beneficial effects of the higher biological value of wholemeal. It is wiser to continue our efforts to supply everybody with sufficient milk than to insist on a greater degree of extraction of wheat. Until we have experiments on young growing children, comparable to those on the laboratory rat, the experiments quoted must remain as a possible pointer only. The rapidly growing rat might well show the effect of the higher biological value of wholemeal less ambiguously than the child. The rat certainly has the power of extracting other things from cereals which the human being does not possess. (See below.)

Then comes the problem of the mineral elements of cereals. The important ones are phosphorus, calcium and iron, of which wholemeal certainly possesses more than 72 per cent. extraction flour.

Phosphorus. White flour has 102 milligrammes per 100 grammes, national wheatmeal 206, and wholemeal (92 per cent. extraction) 287.[2] This appears to be at first sight all in favour of high extraction. But is phosphorus in these amounts essential? Throughout their extensive investigations into diets in this country, McCance and Widdowson have never met diets deficient in phosphorus. Whatever else may be lacking—calcium, iron, protein and vitamins—phosphorus is always there. Moreover, the phosphorus in cereals antagonizes the absorption of calcium, whether it be there as phytates or as phosphates.[3] Free phosphates impede the absorption of calcium, whereas the phytates in 92 per cent. wholemeal, not only prevent the body from obtaining the calcium in wholemeal, but actually prevent the body from obtaining some of the calcium from other sources, such as milk, cheese and fish. It has been calculated by McCance and Widdowson that 1 lb. of wholemeal bread would blanket the calcium in $\frac{9}{10}$ of a pint of milk. In the long run, with the consumption of milk in this country so low as it is, it would be wrong to insist on higher extraction of wheat until the production and consumption of milk is increased by at least 50 per cent. This will take many years.

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[1] Chick and Work. (1941), *Chem. and Ind.*, **60**, 723.

[2] McCance and Widdowson. (1942), *The Chemical Composition of Foods.*

[3] McCance and Widdowson. (1942), *Journ. Physiol.*, **101**, 44, 304.

On the score, then, of phosphorus content, wholemeal is a dangerous food.

Calcium. In calcium content wholemeal flour beats white flour. The figures given by McCance and Widdowson[1] are 34·8 milligrammes and 18·4 milligrammes respectively. Assuming the calcium to be equally available from each—which we have seen they are not—wholemeal provides double the amount of calcium that white flour yields. Put in that way, as it often is by those who " believe " in wholemeal, it sounds convincing. But put in the common-sense way of saying how much wholemeal flour one would have to eat per day to obtain 680 milligrammes, the argument becomes ludicrous. To obtain all the calcium needed by an average man per day, he would have to eat $\frac{100 \times 680}{34{\cdot}8}$ or approximately 1950 grammes (i.e. over 4¼ lb.). This as bread would be some 6¼ lb.—an impossible amount. To eat 1 lb. per day is an achievement, except when taking strenuous exercise. Besides which—to continue flogging a dead horse—the calcium of wholemeal is unavailable. All cereals are poor sources of calcium and what they have is often unavailable and almost certainly unavailable in whole cereals and whole cereal products.

Iron. Again we find that wholemeal (92 per cent. extraction) has more iron than white flour. Figures from McCance and Widdowson's tables are 3·55 milligrammes per 100 grammes wholemeal, 2·36 milligrammes for National wheatmeal, and only 0·92 for 70–72 per cent. extraction flour. Moreover, it has been shown that the laboratory rat, made anæmic by a diet of white bread and milk, can be restored to a normal state of the blood by whole cereals. The rat obtains insufficient iron from white flour, but can gain sufficient from whole cereals. Consequently the assumption was made that the anæmia, so often found in the poorer classes of this and other countries devoted to highly milled cereals, is due to the deficiency of those cereals in iron. And here, among others, we must pillory ourselves, for in the 9th Edition of this book we recommended wholemeal bread for its pleasant flavour and its iron.[1] This illustrates the rashness of applying facts discovered in the rat directly to human dietetics without criticism. It had been known that of the metallic phytates, iron phytate is particularly insoluble. Consequently it might have been guessed that the phytates of whole cereals would impede iron absorption from the human gut. This is true. In prolonged experiments by McCance and Widdowson the percentage absorption of the iron present in the diets of four men and four women sank measurably when the white bread in their diets was replaced by wholemeal bread of 92 per cent. extraction.[2] Though there was 50 per cent. more iron in the wholemeal bread diet, they absorbed less of it. Two of the women actually went into negative balance on the wholemeal bread diet. The authors of this work cautiously suggest in their summary of the experiments that " in spite of the large amounts of iron in whole wheat, bread made from it may not be as good a source of iron as is generally supposed."

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[1] *op. cit.*

Why then do rats recover from a nutritional anæmia produced by white bread and milk when given whole wheat ? Simply because they possess a phytase in their alimentary tract which splits the inositol hexaphosphates into inositol and phosphates. So little a difference does it take to render experiments on rats nugatory when applied to human beings !

It is true that cereals do contain phytases, but in the case of wheat not enough to split the whole of the phytates in bread-making.[3] In rye bread baked according to German technique, 45 per cent. of the phytates were destroyed by the active phytase of rye, but much less disappears in wheaten bread.

So on the score of iron, as well as of calcium, a 70 per cent. extraction flour is more beneficial than a long extraction. Generally speaking, the high mineral element content of wholemeal flour gives it no advantage in diet over white flour, but rather the opposite.

Vitamins. Both white flour and wholemeal flour are deficient in vitamins A, C and D. It was once thought that wholemeal contained some vitamin A but to-day this opinion has been relinquished. The Medical Research Council's tables[4] put its content of A as zero. So there is nothing to choose between the two flours when considering vitamins A, C and D. They have none. Wholemeal flour will have vitamin E, which is of problematic value in human nutrition. But, as we have said, the B vitamins are much better represented in wholemeal flour than in white. Both the germ and the bran contain more thiamine, riboflavine and nicotinic acid than the endosperm. Of the total thiamine in wheat, the germ has 15–20 per cent., the bran 60 per cent., and the endosperm only 25 per cent.[1] This estimate has to be modified somewhat, for it has been found that the scutellum contains 59 per cent. of the total thiamine of the wheat.[2] This probably in ordinary milling is included with the germ, but if it could be retained by "dry milling" in the endosperm, much higher amounts of thiamine would be present in white flour, enough to lay the bogy of avitaminosis B_1 which so terrifies the B enthusiasts. It would be possible to obtain a 76 per cent. extraction flour with no germ or bran in it yet having the thiamine content of national wheatmeal flour.[3] It must be mentioned that all wheats have not the same thiamine value. It is usually assumed that their value is about 1·6 I.U. per gramme.[4] It may be higher. Figures have been given as high as 5.

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[1] *Food and the Principles of Dietetics.* (1940), 133.

[2] McCance and Widdowson. (1942), *Lancet*, **1**, 588.

[3] McCance and Widdowson. (1944), *Nature*, **153**, 650.

[4] *The Nutritive Values of War-Time Food.* (1945.) Some workers claim that what there is, is equally distributed between endosperm and the rest of the wheat berry.

With nicotinic acid the story is much the same: it is to be found concentrated in the bran, the coarsest bran having most. Thus whereas English wheat may have 48 microgrammes per gramme, and Manitoba 55–66, commercial germ has 55–77, and the bran 267–325. A 45 per cent. extraction white flour from English wheat has only 5·0, a 70 per cent. 7·5, an 85 per cent. 10·5, and 100 per cent. 48. Similar but rather higher figures are given for Manitoba wheat, the 1943 wheats having a particularly high titre.[5] National Wheatmeal flour, 85 per cent. extraction, gave figures ranging from 12–18·7 microgrammes per gramme. One pound of national wheatmeal flour would give about 5½ milligrammes of nicotinic acid, a very considerable amount, whereas a 70 per cent. extraction white flour would give but 3½–3¾ milligrammes. The change to 85 per cent. extraction flour has caused the disappearance of pellagra among the mental patients in an institution to which one of us (G. G.) has access. Previously, 4 or 5 patients who were "difficult" over their food had mild pellagra each year.

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[1] RICH. (1941), *Chem. and Ind.*, **60**, 611.

[2] HINTON. (1944), *Biochem. Journ.*, **38**, 214; WARD. (1943), *Chem. and Ind.*, **62**, 11.

[3] WARD. (1943), *op. cit.*

[4] RICH. (1941), *Chem. and Ind.*, **61**, 611; COPPING (1945) in a conference of the Nutrition Society, Feb. 24th, gave figures: 2·8–8·5 μg/g. = 0·28–0·85 mg./100 g. = 0·93 I.U. to 2·83 I.U. per gramme or 93–283 I.U. per 100 grammes.

[5] BARTON WRIGHT. (1944), *Biochem. Journ.*, **38**, 314.

With riboflavine the distribution between bran, germ and endosperm is more even than with B_1 and nicotinic acid, but still the endosperm has least.[1] Therefore as regards the B complex of vitamins, nutrition experts must favour high extraction, though it must not be forgotten that the microbes of the large intestine contribute to the body significant amounts of these vitamins, and it is possible that cereal residues give a less satisfactory pabulum for these microbes than, say, milk residues. Maize contains about the same amount of nicotinic acid as milk, yet milk can cure or prevent the pellagra arising from eating maize!

There remains only roughage to consider. It, or its decomposition products in the large intestine, stimulate that organ to peristalsis. It is generally asserted that some roughage is of assistance to the regular emptying of the large intestine. There is no doubt that whole cereals provoke in the majority of people a much more frequent evacuation, up to thrice a day, of the large intestine. Some alimentary tracts are much more irritable than others. Many cannot tolerate a 100 per cent. extraction material. Indeed there have been frequent grumbles at 85 per cent. extraction National Wheatmeal bread on that account, though only the fine bran is included in National Wheatmeal flour. It is impossible to say how much this fear of the large intestine, inculcated in people by nurses, relatives and the patent food and medicine advertisements, renders them "bowel conscious" and so queers their capacity for sound observation. It has been said that it is somewhat hard on those who have no trouble with their colons to be condemned to frequent and bulky stools in order that the constipated should have regular motions.[2]

To sum up the whole problem as it stands at the present day:

(i) There is no advantage in higher extraction flours as regards protein absorption.
(ii) There may be slight advantage in them as regards the biological value of their protein.
(iii) High extraction flours are much worse than low extraction flours where calcium and iron absorptions are concerned, and this is mainly due to their high content of organic and inorganic phosphorus compounds.

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[1] Cereals in whatever form are a poor source of riboflavine.

[2] Robertson. (1943), *Chem. and Ind.*, 62, 222.

(iv) Both high extraction and low extraction flours are valueless as sources of vitamins A, C and D.

(v) High extraction flour is much better than low extraction flours for the B complex of vitamins.

(vi) High extraction flour sometimes provokes frequent and bulky evacuations of the large intestine which may or may not be advantageous.

It is clear that some compromise between high and low extraction is advisable, and we think that the introduction of National Wheatmeal flour of 85 per cent. extraction,[1] containing the fine bran, the aleurone layer, the scutellum and as much of the germ as possible, and having a thiamine content of nearly 1 I.U. per gramme, was a wise move from a wholly dietetic standpoint and that the fortification of this flour with calcium to offset the phytate effect was an admirable step. Further, we consider that this standard should be maintained until the agriculture of this country has been so reformed that there is plenty of milk, cheese, eggs, fruit, vegetables and bacon for everyone and the economic conditions so changed that everyone can purchase them. As regards wheat the task of the growers is to produce wheat with higher amounts of the B complex of vitamins and the task of the millers is to see that these vitamins find their way into the lower extraction flours demanded by public taste.

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[1] It is interesting to note that the amounts of the useful nutrients in wheat flours—particularly vitamin B_1—show a sudden drop if the extraction be below 85 per cent. Even 82½ per cent. extraction flour shows a marked decrease. The change to 80 per cent. extraction we feel to be a mistake. We append an analysis by McCance and others (1945), *Bioch. Journal*, 3v, 213, *q.v.*

Composition of Manitoba and English Flours.

	g. per 100 g.						
Extraction.	Protein (N × 5·7)	Fat.	Carbohydrate as starch.	Fibre.	Calories per oz.	Vitamin B_1.	
Manitoba, 80 per cent.	13·2	1·4	68·8	0·13	96	65	I.U. per
,, 85 ,, ,,	13·6	1·7	67·2	0·33	97	92	100 g.
English, 80 ,, ,,	8·2	1·3	73·5	0·19	96	60	
,, 85 ,, ,,	8·6	1·5	72·0	0·42	95	84	

	mg. per 100 g.					
Extraction.	Riboflavine.	Nicotinic Acid.	Calcium.	Iron.	Total Phosphorus.	Phytate Phosphorus.
Manitoba, 80 per cent.	0·08	1·1	15·4	—	139	63·4
,, 85 ,, ,,	0·10	1·3	18·5	—	188	96·1
English, 80 ,, ,,	0·08	0·9	21·5	1·65	118	57·8
,, 85 ,, ,,	0·12	1·1	24·5	2·22	153	72·8

COOKERY OF FLOUR—BREAD

In order to make flour available as food, it must be cooked in some way or another. The simplest method is to mix the flour with water and bake it. It is in this way that ***ship's biscuit*** is manufactured. The product, however, is of an almost flinty hardness, and not easy of mastication. Hence the problem early arose, how to cook the flour in such a way that it would be light and easy of digestion. It was solved by causing gas to develop in the mixture of flour and water, so converting the latter into a kind of sponge, which was subsequently baked, and into which the digestive juices can easily penetrate. In other words, man learnt to make ***bread.*** Now, the making of bread from flour is only possible because the latter contains gluten. Gluten is a mixture of proteins, which has the peculiar property of becoming viscid when mixed with water. If the viscid mass is then blown up with gas, it has sufficient cohesion to remain in the form of a sponge or honeycomb, instead of collapsing again, as it otherwise would do, and allowing the gas to escape. As we have said above, most other cereals, such as barley, rice, and oatmeal, do not contain gluten, but other forms of protein, which do not become viscid when moistened, and consequently out of these bread cannot be made.

The next question is, How is the gas, which is to be used to blow up the dough, produced ? The reply is that the earliest method of producing the gas, and that which is still by far the most widely used, was by ***fermentation.*** There are in the air " wild " yeasts which falling on a wet dough produce from the sugar in the dough alcohol and carbon dioxide.[1] This must have been the method by which the Egyptians and the Jews " leavened " their bread. Some dough reserved from the last baking was added to a fresh dough, the yeast it contained grew with great rapidity through this dough till all was ***leavened*** and filled with bubbles of gas.[2]

In more modern times strains of yeasts have been produced commercially and standardized, and these are what are used today for the manufacture of bread.

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[1] AMOS. (1942), *Chem. and Ind.*, **61, 117,** has given convincing evidence that the flour itself contains a yeast which must be responsible for the gasification of the barm in the Scottish method of making bread, and possibly in the leaven of Biblical times. This paper and the relevant chapters of *Modern Cereal Chemistry* by Kent-Jones should be consulted by anyone interested in the reasons for the different flavours and textures of bread in various parts of the British Isles.

[2] This method was still actually in use in remote farmhouses in the early childhood of the authors.

It is not the object of this book to deal with processes of cooking except in so far as they bear upon dietetics, so no elaborate account of the baking of bread is given here. That is left to trade journals and cookery books, but we cannot refrain from saying that the latter make the process of breadmaking terrifyingly elaborate, whereas it is so easy that almost anyone can make a success of it.

In using yeast to make bread, the first thing the baker has to do is to get his yeast to increase and multiply. This has two advantages: it enables an originally small quantity of yeast to suffice for a whole sack of flour, and it produces a more active yeast, for the young cells are more energetic than those which are older. This stage of bread-making is called the preparation of the ***ferment***. The yeast is mixed with sugar and warm water and put in a warm place till it froths up. This takes but a short time. The invertase of the yeast splits the cane sugar to glucose and fructose and the zymase within the yeast cells begins the fermentation of the glucose to carbon dioxide and alcohol. There are other and more elaborate ways of producing a "ferment," e.g. by the use of potato gruel, flour and yeast, but the object is to obtain an actively growing yeast.[1]

This ferment is then mixed with warmed flour and warm water and the whole kneaded into a dough. The yeast continues its production of carbon dioxide within the dough, partly at the expense of the sugar added and partly by working on the maltose produced by the diastatic ferments of the flour acting on its starch. The dough is thus blown up into a sponge-like texture. It rises. How long it is left to rise varies greatly and depends largely on the amount of ferment used, and the temperature of the surroundings. It can be as little as 20 minutes. In the usual household practice it is an hour. In commercial bakeries it is about 4 hours, but it may be, in more economical parts of these islands, much longer still. This has some bearing on the destruction of the phytates present. The longer the dough is "proved" the more work the phytases of the flour can accomplish with advantage in reducing the rachitic effect of cereals.

When the dough has risen to about 1½ times its original volume it is usual to knead it thoroughly again, leave it again to rise in a warm place and when it has sufficiently risen to weigh out portions and bake it at a temperature of 400°–450° F. This second kneading, invariably carried out in commercial practice and in domestic science colleges, can be omitted both with wholemeal bread [2] and with white bread in the household.[3]

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[1] See Amos, *op. cit.*

[2] Grant. (1944), *Your Daily Bread.*

[3] Personal communication from two housewives.

The baking causes the gas in the dough to expand and blow the latter up so that it becomes full of little cavities. The heat also hardens and coagulates the proteins in the flour. Some of the starch on the outside is converted to soluble starch and dextrin and forms the crust. It is to the dextrin that the crust owes its glazed appearance. Altogether about 8 per cent.[1] of the starch in the loaf is thus converted. Some caramel also is formed, and helps to give the crust its flavour and dark colour. When these changes have taken place the dough has passed into the form of bread.

Changes involved in Baking. It will be obvious that any process of making bread by fermentation necessarily implies an amount of waste. The amino-nitrogen of the flour forms a pabulum for the yeast.[2] Other organisms break down some of the protein to amino-nitrogen. The sugar of the flour is utilized by the yeast and starch split into sugar. This produces, as said above, alcohol and carbon dioxide. The gas diffuses out of the bread and the alcohol is mostly driven off by the heat of the oven. It was calculated that, as long ago as 1879, 300,000 gallons of alcohol were annually lost in this way in the ovens of London alone. It does not pay to recover this alcohol. Totalling these losses it has been calculated that as much as 7 per cent. of the total solid ingredients of the dough are lost.

The consideration of this inevitable waste led to attempts to convert dough into a porous form by other methods than that of fermentation. One of these was the method of Dauglish. In this process carbon dioxide was prepared in the usual chemical way; water was saturated with it at 7 to 10 atmospheres; and the dough was mixed with this in an air-tight chamber. Then the pressure was lowered and the dough allowed to expand, was cut into loaves and baked at once. The product was known as ***aerated bread.*** The process has, however, fallen into desuetude. The bread so produced had a raw and insipid flavour.

Results similar to the above are also obtained by the use of ***baking-powders.*** These consist of mixtures of various chemical substances, which have this in common, that when moistened the ingredients of the powder act upon one another, carbonic acid being given off. If, therefore, the powder has been thoroughly mixed with the flour, and water is added, the gas will be liberated all through the resulting dough, and the latter will be thoroughly aerated. These powders consist of either tartaric acid or potassium hydrogen tartrate with bicarbonate of soda. Some used in the U.S.A. have alum in them. A means of introducing calcium into bread would be to make precipitated chalk the basis of a baking-powder. The tartaric acid powders are the most efficient, for they give off twenty-five times their volume of gas; the cream of tartar powders yield only thirteen volumes, and alum powders not more than seven to eleven. In all of these powders the soda is slightly in excess, so that the end reaction of the chemical process is alkaline. There is thus no possibility of their rendering the bread sour. "Self-raising" flour is flour with which baking-powder has already been mixed. Although the use of baking powders obviates the protein and carbohydrate loss from the dough, there is considerable destruction of vitamin B_1, which does not occur when yeast is used. In yeast-made bread the loss is about 10 per cent. In baking-powder-made bread the loss may be as much as 100 per cent., depending upon the final P_H reached. Hence baking powders should not be used if there is any fear of lack of vitamin B_1.

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[1] *U.S. Dept. of Agriculture Bull.* 67.

[2] Amos. *op. cit.*

No matter by what process a loaf is made, it possesses, when finished, certain characters by which bakers judge of its quality. It should be well "risen," and possessed of a thin flinty crust, which is neither very light nor very dark in colour, and cracks on breaking. The crumb should be elastic in consistence, of uniform texture without large holes, and of a smooth and silky "pile." It should have a sweet, nutty flavour and odour, and in colour should be of a creamy whiteness. Curiously enough, when bakers speak of a loaf having "no colour," they mean that it is rather dark, whereas "high colour" signifies with them great whiteness. It must be admitted, however, that the above characters, however important æsthetically, are not of much value from a nutritive point of view. Especially is this so in regard to colour. A very white loaf means a loaf in which starch is at a maximum and protein at a minimum, and that is theoretically not desirable. For setting up a false standard of whiteness the baker is not to blame. It is the ignorance of the public, which mistrusts a dark loaf.

The Chemical Composition of Bread. Two-thirds of the volume of a good loaf is made up of gas (Fig. 15), and of the solid part about 40 to 50 per cent. by weight consists of water, so that bread is one of the least watery of vegetable foods, and is relatively much less so than raw meat.[1] The composition of the dry residue will obviously depend upon that of the flour from which the bread has been made. Especially has one to consider whether the bran and the germ have been left in the flour or not. In white bread these have been excluded. As regards "brown" breads one cannot speak so definitely, for the term ***brown bread*** is a vague expression.[1] It may simply mean that a certain proportion of bran or of germ or of both have been added to the flour, or it may be applied to bread made from whole wheat meal. In each case the resulting loaf will be "brown." Now, bran contains, as we have seen, a good deal of inorganic matter, protein, and vitamins of the B complex. One would naturally expect, therefore, that bread containing bran should be richer in these ingredients than white bread. As regards inorganic matter this is certainly true, but it is by no means invariably true of protein. The following table shows in round numbers the mean percentage composition of different breads. Unfortunately the reader must be prepared to meet analyses which do not agree with those quoted, which are from McCance and Widdowson.[2] For example, those given by the Medical Research Council [3] for National Wheatmeal bread are: Protein 8·5, Fat 1·2, Carbohydrate 51·4, Calcium 57 milligrammes, Iron 1·8, Calories per lb. 1142. Such variations are inevitable and depend upon the source of the bread and not on the analyst.

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[1] The great variability in the amount of water met with in bread renders it desirable that some standard of moisture should be fixed, the exceeding of which should be regarded as an adulteration. In other words, when a consumer pays for a given weight of bread he has a right to expect that his purchase shall contain a definite amount of nutriment. The figure given for the water in National Wheatmeal bread in *The Nutritive Values of War-time Foods* is 37 per cent.

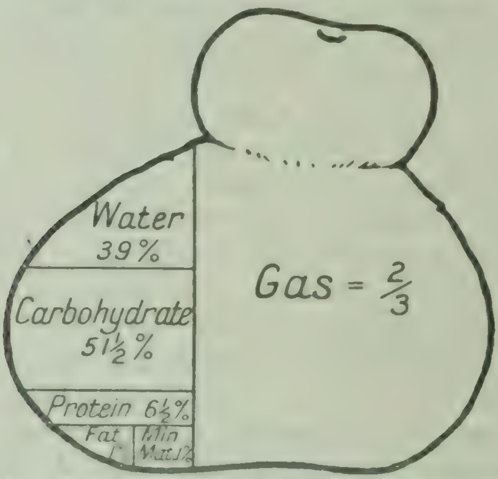

FIG. 15.—DIAGRAMMATIC REPRESENTATION OF THE COMPOSITION OF A LOAF.

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[1] "Graham flour," invented by the American physician, Dr. Sylvester Graham, alone contains the entire grain. In making "wholemeal" the outer and more flinty layers of the bran are removed.

[2] *Chemical Composition of Foods.* (1942), *Med. Res. Council Special Rep.* No. 235.

[3] *The Nutritive Values of War-time Foods.*

Composition of Wholemeal and White Bread compared

	Protein.	Fat.	Carbo-hydrate.	Cal-cium.	Iron.	Calories per lb.
				mg.	mg.	
White bread (70–72 per cent. extraction) .	7·9	0·7	53·7	23·1	1·00	1093
National Wheatmeal bread (85 per cent. extraction) . . .	10·0	1·6	45·3	22·3[1]	2·32	1021
Wholemeal bread (92 per cent. extraction)	10·8	2·2	44·0	25·3	2·60	1041

There are also various ***patent and fancy breads*** in the market. Of the former the different varieties of ***Vienna bread*** are a good example. These are made from very fine flour (" patents ") fermented with compressed yeast, milk being often added to the dough. The crust is glazed by being subjected to the action of superheated steam before leaving the oven. Of the patent breads, the majority are of the " brown " variety. They are made from flours prepared by various patent processes. Some of them are ***wholemeal*** breads, in which the bran has been reduced to varying degrees of fineness ; others contain the germ in various proportions, of which " Hovis " is the best-known example. Others, again, are ***malted.*** The malting of bread consists in adding to it malt-extract, obtained by evaporating an infusion of malted barley to a syrupy consistency at a low temperature. The solid part of the malt-extract so prepared consists mainly of malt-sugar and dextrins. But it also contains the ferment diastase, which is able to convert starch into soluble substances (maltose and dextrin). When, therefore, malt-extract is mixed with the dough, part of the starch in the latter is ultimately converted into malt-sugar and dextrin. In other words, part of the starch is digested. This has the effect, as already pointed out, of making the bread keep longer moist. Now, it is important to remember that this ferment diastase is readily destroyed if exposed to a high temperature. Hence its activity inevitably ceases soon after the bread enters the oven. If, then, any considerable part of the starch of the dough is to be converted, the malt-extract must be added very early in the process. As an alternative to that it may be added to a separate part of the flour, and the latter mixed with water and kept at a moderate temperature till most of its starch has been changed, and this mixture added to the dough just before baking. This is the peculiarity of Montgomerie's process, by which "Bermaline" bread is made. But even in these favourable conditions not much more than 10 per cent. of the carbohydrates of the loaf are in a soluble form, while in ordinary bread about 4 per cent. are so changed. Seeing, also, that the diastase is destroyed by the act of baking, it is obvious that malted bread cannot truly be said to aid the digestion of other starchy foods. Detailed analyses of patent breads made by Hutchison will be found in an earlier edition of this book. Any advantage these breads, with the exception of the germ breads, have over normal bread lies more in their palatability and flavour than in their nutritive value.

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[1] 57 when fortified, according to *The Nutritive Values of War-time Foods.* (1945.)

Changes which Bread undergoes on Keeping. When bread is kept its crust loses its gloss and elasticity and becomes soft, leathery, and dull. At the same time the crumb becomes "dry" and hard. The crust takes up water from the air and from the crumb. The change in the crumb is not only, as might have been guessed, due to loss of water but due to a change in the aggregation of the molecules of starch. Starch, according to Kratz, who examined its X-ray spectrograph, has three forms: A, that of unchanged wheaten starch; B, that of "native" starch; and C, that of fresh baked crumb of bread. On staling, the starch of type C reverts to that of type B. This change is reversible and depends on temperature and humidity. A stale loaf may be "rejuvenated" several times by a short time in a sharp oven. Type B starch is again changed to type C.

The ***cooking of bread*** is practically confined to the application of dry heat. This has the effect of driving off water, and of rupturing some of the starch grains, and converting them partly into soluble starch and dextrin. A little caramel also is produced. The result is toast. Toasted bread has the composition: Protein 9·4, Fat 0·8, Carbohydrate 63·8, and Caloric value per lb. 1300 (per oz. 81). "Pulled bread" is made by pulling out the interior of a new loaf and thoroughly baking it. The same changes occur in it as in toast, only to a greater degree. "Fairy toast" or toast Melba is made from new bread, cut thin, and baked in a slow oven till it is a delicate golden brown, or from thick toast which is split down the middle and the fresh side toasted.

Biscuits are made from fine flour either alone or with the addition of sugar, butter, milk, flavouring agents, etc. Baking-powder is sometimes added to make them rise a little. They contain very little water (about 5 per cent.), and 3 lb. of them may be taken as equal in nourishment to 4 or 5 lb. of bread, according to the make of biscuit.

Analysis of a number of biscuits made by English firms are given below; attention is called to the high percentage of fat in many kinds, particularly the cream cracker.

COMPOSITION OF BISCUITS

	Protein.	Fat.	Carbo-hydrate.	Calories per oz.
Army (round)	13·1	1·2	75·2	106
„ (square)	11·9	0·3	76·3	103
Bisc-o'-Rye	11·90	1·10	76·00	105
Breakfast	10·40	9·20	74·86	123
Chocolate	4·69	6·15	70·20	103
Cornish Wafer	7·25	29·28	58·87	154
Cracknel	11·58	8·38	73·91	121
Cream Cracker	8·08	18·43	70·62	140
Dinner Roll	10·49	6·34	74·39	115
Fancy Lunch	9·86	7·17	78·88	122
„ „	11·60	8·63	72·70	122
Fine Water	11·95	7·33	75·03	120
Fruit Wafer	5·40	10·64	72·18	119
Ginger Nut	6·10	8·50	79·80	119
Horlick's Malted Milk Rusks	9·30	4·30	80·00	115
Marie	7·43	10·80	79·47	129
Milk	9·23	10·72	76·85	125
Nursery	9·33	3·67	78·80	112
Osborne	7·40	11·10	79·59	130
Oval Thin Captain	9·25	6·38	79·46	120
Oval Water	9·96	6·88	78·00	120
P.F. Shortcake	8·02	26·40	62·40	151
Princess	8·20	24·00	63·10	147
Thin Captain	11·28	1·68	80·31	120
Ryvita	7·4	2·1	86·8	106
Water	8·73	4·07	81·75	116

Rusks may be regarded as a kind of toast. They are made in much the same way as bread, but sometimes with the addition of butter, sugar and milk, and are twice passed through the oven, after which they are thoroughly dried.

The Digestibility of Bread. The term digestibility in dietetics is a loosely used term to denote a number of properties. To the physiologist it means ease and rapidity of digestion and absorption into the blood stream; to the physician it means these plus lack of discomfort in the process. If the eating of a food is followed earlier or later by pain or discomfort, that food is apt to be labelled "indigestible." It may produce flatulence in the stomach or bowel; it may evoke a large flow of gastric juice and promote excessive peristalsis of stomach or intestine; the peristalsis of the stomach and small intestine may hurry the food in a semi-digested state into the colon and microbes there may produce flatus, offensive or otherwise; the peristalsis may be so great as to cause diarrhœa. Any food which does any of these things is "indigestible." At one time great attention was paid to the length of time food remained in the stomach, but this, we consider, is no sound measure of its digestibility.

Voit, in his lectures, used to protest against the idea that awareness of the workings of the alimentary tract indicated that the food eaten was indigestible. He maintained that all it showed was that the alimentary tract was at work. This we hold to be unfounded, for we consider that digestion is best when effortless and unconscious. Bread is digestible and absorbable. The digestion starts in the mouth by the conversion of its cooked starch and its dextrins into dextrins and maltose under the influence of the diastatic ferment of the saliva known as ptyalin. The more thoroughly the bread is chewed and ground into small particles, the more complete will the transformation be. It is on account of the greater ease with which they can be pulverized by the teeth that toast and biscuits are more easily digested than ordinary bread, and stale bread than a newly-baked loaf. The dryness of toast and biscuits, too, enables them to become easily saturated with the saliva, and that also greatly facilitates digestion. Further, it must be remembered that a considerable proportion of the starch in biscuits and toast has been already converted into soluble forms in the course of their preparation, so that the labours of the digestive juices in their case are considerably lightened. For these reasons also the crust of bread is more digestible than the crumb, for it is drier, and contains a higher proportion of dextrins, owing to the more intense action upon it of the heat of the oven.

The notorious indigestibility of new bread, on the other hand, is due to its moistness, which makes it difficult to chew, and at the same time prevents it from soaking up the saliva. Alvarez reports that new bread can pass the whole of the small intestine without becoming digested. (Observations upon a patient with ileal fistula.)

As regards the ***duration of its stay in the stomach,*** bread leaves the stomach with good speed. Hawk and Bergheim report that 100 grammes of bread (3½ oz.) leave the stomach completely in 2½ hours. This period cannot really be regarded as long when one bears in mind the comparatively large amount of solid matter which bread contains. White bread is disposed of by the stomach rather more quickly than black (e.g. rye), but there is no appreciable difference in this respect between the behaviour of wholemeal bread and that made from fine flour. Biscuits must be regarded as considerably more digestible than ordinary bread in view of the large amount of solid nutriment which they contain.

In the intestine the digestion of the starch and protein of bread is completed, and ***absorption*** takes place. On the whole, white bread is very thoroughly absorbed. Even when large quantities are consumed, the loss of nutritive constituents is only about as follows :[1]

	Percentage Unabsorbed.
Total solids	4½
Protein	20[2]
Inorganic elements	25
Carbohydrates	3

It will be noted that a great share of loss falls to the proteins. This contrasts very strikingly with the case of meat, in which the protein is absorbed almost in its entirety.

The ***carbohydrate*** of bread corresponds to the protein of meat in being almost completely absorbed into the blood. On the other hand, it is rather surprising to find that, of the comparatively small amount of ***inorganic elements*** met with in bread, one-fourth is excreted unabsorbed.

We have already (pp. 308–17) discussed the still hotly debated question of the relative nutritional values of white and wholemeal bread. For the middle classes in peace-time this seems as important as the question as to which end you should open an egg. The future seems to lie with a fortified bread.

On the evidence, then, bread, unless it be new, is a highly digestible and absorbable food. It is unlikely to provoke any of the symptoms which will cause it to be labelled indigestible. Even the eating of hot newly baked bread, so usual for breakfast in the United States, does not seem to be followed by the symptoms which would be expected in this country. Four years' residence in North America by one of us did not reveal more indigestion in that part of the world than in Great Britain. It was common once to speak slightingly of the American stomach, but perhaps that term of abuse may be allowed to pass into desuetude.

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[1] From the average of a considerable number of experiments by Rubner, Atwater, Zuntz and Magnus-Levy, Goodfellow and others. The quantities consumed were very considerable, amounting to from 600 to 1000 grammes per day.

[2] The latest figures quoted above, p. 311, give the loss of protein as much lower, viz. 9 per cent. for white bread and 15 per cent. for 100 per cent. extraction wholemeal bread.

The Economic Value of Bread. Bread is among the cheapest of foods. That is why it forms so large a proportion of the diet of the poorer paid classes. A labourer, doing heavy manual work, can easily consume 1 lb. of bread per day. He needs cheap and easily available energy and that is supplied by bread. With so much more of our manual work being done by machinery and with an absolute rise in wages of the working classes we may expect the consumption of bread and other cereal products to decrease. This tendency was obvious in this country between the opening years of the century and the outbreak of war in 1939. As war circumstances caused a fall in the fat ration, the other main source of Calories, the consumption of bread rose again and in diets investigated by McCance and Widdowson before and after the commencement of the war the Calories obtained for carbohydrate almost exactly equalled those lost in fat. Bread, then, has its prime importance in supplying Calories.

It is difficult in a time of fluctuating prices to give figures which will be accurate for more than a year or so. But it is easy to work out the cost per thousand Calories given tables and current prices. At the time of writing margarine at the controlled price of 5*d*. per lb. gives 1000 Calories at approximately 1½*d*.; of 9*d*. per lb., at 2½*d*. Bread at 3*d*. per lb. gives 1000 Calories at 3*d*.; Cheese at 1*s*. 1*d*., at 6½*d*., milk at 9*d*. per quart, at 1*s*. 0*d*., jam at 1*s*. 0*d*. per lb., at 10½*d*. and potatoes at 1*d*. per lb., at 2½*d*. These prices are controlled and some of the foods are at an artificial price due to Government subsidies, but even in times of peace, bread and margarine helped down with a little jam are the cheapest foods and easiest to prepare. In other countries other cereals may take the place of wheat products, but the reason is the same: cereals are cheap for Calories. That is why the Government in the two World Wars has refused to ration bread, and in the second World War kept its price artificially low.

Bread, too, is by no means a negligible source of protein, albeit of second quality. In fact a high bread diet entails a high total protein diet, 1 lb. of bread contains over 38 grammes of protein, no mean proportion of the 70–80 grammes held to be essential in the daily diet of an adult. In this no other cereal can equal wheat. And the cost of wheat protein is low compared with that of other foods. Beans at 6*d*. per lb. are the only food which rival bread as a source of protein in price. Both give 1 lb. for about 2*s*. 10*d*. Cheese gives, at 1*s*. 1*d*. per lb., the same amount at 3*s*. 5*d*., whereas with milk the price is 9*s.* 11½*d.* when milk is bought at 9*d.* per quart. The serious defects of bread are its low calcium content and its total lack of vitamins A, C and D; only in the vitamins of the B complex is bread of use, wholemeal being better than white bread. There is no escape from the fact that bread must continue to be the largest single element of diet, mainly, because of its cheapness as a source of energy.

Of the patent and fancy breads as a whole it may be said that they are somewhat dearer than white or wholemeal breads. One pays for flavour and the patent rights. Even ordinary wholemeal bread has ceased to be cheaper than white bread and cannot be recommended on that ground. Here are some analyses of different breads from McCance and Widdowson's tables: [1]

	Protein.	Fat.	Carbo-hydrate.	Cal-cium.	Iron.	Calories per oz.
	Per 100 grammes.					
	g.	g.	g.	mg.	mg.	
Bread:						
Currant	7·0	3·4	45·8	37·6	2·35	66
Hovis	11·4	3·7	40·6	27·5	2·95	66
Malt	9·1	3·3	49·4	53·0	3·21	72
National Wheatmeal, 85 per cent. . .	10·0	1·6	45·3	22·3	2·32	65
National[1] Wheatmeal, fortified with Calcium	8·5	1·2	51·4	57·0	1·8	74

The most important preparations of wheat flour, especially in Italy, are macaroni, spaghetti, vermicelli and the Italian pastes. These are made from flours rich in gluten derived from a different species of wheat, *triticum durum*, whereas ordinary wheat flour arises from varieties produced by thousands of years of selection and, nowadays, controlled breeding and selection of strains of *triticum vulgare*. *Triticum durum* is a hard, yellow, flinty wheat having a high protein and sugar content.[2] It needs a hot climate and is resistant to drought. The flour from the endosperm of the wheat is made into a paste with water and the viscidity of the gluten then allows it to be moulded in various ways.

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[1] McCance and Widdowson. (1942), *Chemical Composition of Foods*, Med. Res. Council Special Report 235.

[2] Kent-Jones. (1939), *Modern Cereal Chemistry*, Third Edition, 46–8.

The composition of products made from *triticum durum* flour are given below.

	Protein.	Fat.	Carbo-hydrate.	Cal-cium.	Iron.	Vitamin B_1	Calories per lb.
				mg.	mg.	µg.	
Macaroni (raw)[1]	10·7	2·0	69·3	26	1·4	75	1532
,, ,, [2]	11·7	2·0	77·0	26	1·43	—	1615
Vermicelli ,, [3]	12·5	0·8	75·5	—	—	—	1624

The preparations when boiled take up a large amount of water. Analyses by McCance and Widdowson [4] give: Protein, 3·6; Fat, 0·6; Carbohydrate, 23·7; Calcium, 8·1; Iron, 0·45; Calories per lb., 504; so that approximately cooked products have three times as much water as the raw. They are very well digested and absorbed according to Rubner.

There are very many other preparations of wheat on the market, whether from whole wheat, wheat with some of the bran removed or from the endosperm. One of the commonest is **Semolina,** prepared from the endosperm of hard wheats. It is used in making puddings, porridge and for the thickening of soups. It contains about 11 per cent. of protein. Below are given the composition of this and other preparations of wheat.

	Protein.	Fat.	Carbo-hydrate.	Cal-cium.	Iron.	Vitamin B_1	Calories per lb.
				mg.	mg.	µg.	
Processed Bran[5]	10·9	4·2	54·5	98	12·9	—	1355
,, Germ[5]	32·0	7·7	37·8	58	9·7	2100	1581
Flaked Wheat [5]	13·9	2·3	66·0	34	4·9	40	1542
Puffed ,, [5]	13·7	2·3	66·1	34	4·7	15	1542
Semolina [5] . .	10·7	1·8	69·8	18	1·0	90	1538
Vita-weat [4] .	9·4	10·3[6]	68·1	44	3·4	—	1768

[1] *Nutritive Values of War-time Foods.* (1945), Medical Research Council.

[2] *Chemical Composition of Foods.* (1942); McCance and Widdowson. *Med. Res. Council Spec. Report* 235.

[3] Quoted from the *Analyst.* (1898), 178.

[4] McCance and Widdowson. (1942), *op. cit.*

[5] *Nutritive Values of War-time Foods.* (1945), Medical Research Council.

[6] Evidently fat is added in the manufacture.

Shredded wheat is a preparation of whole wheat in the form of shreds or flakes, which have been cooked to the consistence of a biscuit, and represents the whole grain in a very digestible form.

Force consists of malted whole wheat in the form of flakes, cooked with steam. It is easily digested, but not really of higher nutritive value than fine wheaten biscuits (see p. 325).

Grape-Nuts is another malted preparation of the entire wheat berry, which requires no cooking. It contains a high proportion of soluble carbohydrates, as well as a considerable amount of protein.

Besides these there are many other patent preparations too numerous to mention. It is not unfair to say that these patent foods are a means of selling cheap wheat products at an enhanced price to the public, who pay willingly for convenience, palatability and, possibly, imaginary medical values, what they would not pay for the straightforward virtues of the normal product.

ANALYSES [1]

	Protein.	Fat.	Carbo-hydrate.	Cal-cium.	Iron.	Calories per lb.
				mg.	mg.	
Force	10·2	1·9	75·8	66·3	3·98	1565
Grape nuts . . .	12·8	3·0	71·0	47·8	5·64	1567
Shredded wheat .	10·6	2·8	79·0	34·8	4·48	1660

OATS

Oats at first sight appear to be the most nutritious of all cereals. They are rich in nitrogenous matter and inorganic substances, and are peculiarly rich in fat, the only other cereal which can at all compare with them in that respect being maize. Carbohydrates are present to the extent of about 73 per cent. Further, of the total nitrogenous matter, 94 per cent. is in the form of proteins, two, avenalin and gliadin, being soluble, and avenin, insoluble in water or dilute alcohol. The distribution of the amino-acids in the combined proteins shows them to be complete proteins and therefore available for tissue-building. Unfortunately, the husk of oats is closely adherent, and cannot be entirely separated from the kernel, so that by the ordinary methods of grinding a good deal of cellulose is left in the meal in the form of small sharp particles. These act as stimulants to the intestine, and make oatmeal a valuable food where the intestinal movements are sluggish, but, on the other hand, are apt to prove rather irritating to some persons.

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[1] McCANCE and WIDDOWSON. (1942), *op. cit.*

Oatmeal disagrees with some individuals, and dermatitis may develop. Horses liberally supplied with oats become excitable. They contain calcium magnesium inositol hexaphosphate, the rachitogenic material of cereals in great amount. Oatmeal is one of the few vegetable foods which contain some uric-acid formers (purine bodies).

There are various ways of preparing oats for human food. They may be simply cleaned and ground, the result being ***oatmeal*** of various degrees of fineness, or the branny particles may be separated, and the "oat flour" alone used. ***Groats*** consist of oats from which the husk has been entirely removed; when crushed, Embden groats result.

Rolling is now often employed as a method of preparing oats, instead of grinding. The great pressure to which the grains are subjected between the rollers ruptures the cell walls, breaks down the cellulose, and flattens the grains out so that they are more easily softened by cooking. By the application of heat during the rolling process, the grains are at the same time partially cooked. This not only has the advantage of rendering subsequent preparation for the table considerably less laborious, but also alters the fat, which is so abundantly present in oats, in such a way that it is less liable to become rancid, so preserving the natural flavour of the grain.

"Quaker Oats" is one of the best known of these preparations. "Waverley Oats" and "Provost Oats" are Scottish examples. The composition of some special preparations of oats is shown in the following table:

Preparations of Oats

	Scottish Oat-meal.	Irish Oat-meal.	"Quaker Oats."	Scott's Oat Flour.	Robinson's Groats.
Water	5·0	5·0	7·8	5·8	10·4
Protein	14·6	13·4	14·7	10·0	11·3
Fat	10·1	8·8	6·2	5·0	6·5
Carbohydrates . .	65·1	68·4	69·8	77·9	70·4
Cellulose . . .	3·1	1·7			
Inorganic matter .	2·1	2·0	1·5	1·3	1·7

More modern analysis of ordinary oatmeal give the following figures:

Percentage Composition of Oats

Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Phosphorus.	Vitamin B_1	Calories per oz.
g.	g.	g.	mg.	mg.	mg.	μg.	
12·1	8·7	65·5	55	4·1	—	450	110 [1]
13·3	8·7	72·8	55	4·1	380 [2]	—	116 [3]

Oatmeal contains large amounts of potassium (368 mg.), magnesium (113 mg.) and sulphur (155 mg.) per 100 grammes.

The composition of some oatmeals, when prepared ready for eating, is as follows:

Composition of Rolled Oats when Cooked [4]

	Water.	Protein.	Fat.	Starch.	Cellulose.	Mineral Matter.
Quaker Oats .	92·48	1·65	0·32	6·24	0·09	0·24
Provost Oats .	88·44	2·00	0·36	9·00	0·16	0·24
Mother's Oats .	89·72	1·92	0·45	8·70	0·15	0·18
Oatmeal Porridge[3]	89·1	1·5	0·9	8·2	—	—

The enormous amount of water porridge contains will be observed. A 7 oz. serving of porridge will contain but $\frac{3}{4}$ oz. of oatmeal and supply but 90 Calories. The value of porridge at breakfast lies in the additions of cream or milk to it, not in its intrinsic properties. In fact, because of the difficulty in cooking oatmeal and its low Calorie value for its bulk, porridge is not to be recommended to the working classes.

Plasmon Oatmeal, made from plasmon and oatmeal, originally contained 20 per cent. protein and 8 per cent. fat. During the war of 1939–45 the amount of plasmon added was reduced on account of the difficulty in obtaining milk products. It is precooked, and of very high nutritive value.

Owing to the absence of gluten, oatmeal is unfitted for bread-making, and is usually simply mixed with water and made into cakes. By mixing fine oatmeal with an equal quantity of wheat flour, however, a fairly good loaf can be obtained. A given weight of oatcake (made without butter) contains rather more than twice as much building material as an equal quantity of bread, and has almost twice as great a fuel value.

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[1] *The Nutritive Values of War-time Foods.* (1945), Med. Res. Council.

[2] 70 per cent., i.e. 266 milligrammes is phytate phosphorus. McCance and Widdowson. (1942), *Chemical Composition of Foods, Med. Res. Council Special Rep.* 235.

[3] McCance and Widdowson. *op. cit.*

[4] Williams. (1907), *J. Amer. Chem. Soc.*, **29**.

Oatmeal requires to be very thoroughly boiled in order to soften the cellulose which it contains. "Brose," which is made by merely stirring oatmeal into boiling water, is not a food for delicate stomachs. As regards the ***absorbability*** of oats, experiments show [1] that porridge made from rolled oats, even if taken in considerable quantities, is very well absorbed. Roughly speaking, 95 per cent. of its protein, 93 per cent. of its fat, and 96 per cent. of its carbohydrates enter the blood, whilst 92 per cent. of the energy which it yields is "available" in the body. This compares very favourably with the results yielded by bread. On purely chemical grounds, oats compare to advantage with wheat as a source of nutriment.

MAIZE (INDIAN CORN) [2]

Maize is not so largely used as human food in Great Britain as it might be, but throughout America it forms a staple article of diet, while in Mexico and South Africa maize is literally the "staff of life." It was introduced into Ireland at the time of the potato famine in 1848, and has since established a place for itself in the dietary of the people in that country.[3]

Chemical analysis shows that maize is quite as nutritious as wheat in all except its inorganic ingredients. It is richer in fat than any cereal except oats, containing twice as much of this important constituent as wheat or barley, and three times as much as rye. In nitrogenous matter it is slightly inferior to most other cereals, but fully 87 per cent. of this is in a protein form. As regards its digestible carbohydrates, it is equal to wheat, but somewhat inferior to barley or rye. The average composition of maize products is: [4]

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[1] U.S. Dept. of Agriculture, Bull. 101, 1901, p. 47 (Off. of Experiment Stations).

[2] For much practical information on the use of maize as a food, see U.S. Dept. of Agriculture's Farmers' Bulls., Nos. 559 and 565, 1913 and 1914.

[3] For details of the milling of maize, see KENT-JONES. (1939), *Modern Cereal Chemistry*. Third Edition, 463.

[4] THOMPSON. (1917), Report to Food (War) Committee of the Royal Society.

	Protein.	Fat.	Starch, Sugar, etc.	Fibre.	Ash.[1]	Water.	Cal. per lb.
Whole maizemeal, unbolted	8·7	4·7	71·1	2·2	1·3	12·0	1690
Whole maizemeal, bolted	8·9	4·9	72·0	1·2	1·0	12·0	1765
Maizemeal, granulated (semolina)	9·2	1·9	74·4	1·0	1·0	12·5	1770
Maize flour	7·1	1·3	77·5	0·9	0·6	12·6	1630
Cornflour (corn starch)	—	—	90·0	—	—	—	1675
Flaked maize	9·3	3·48	72·43	1·77	1·18	11·84	1663

Biologically, the mixed proteins of maize stand high in the list of values, though zein, one of them, is deficient in tryptophane, lysine, and cystine. Maize contains much calcium magnesium inositol hexaphosphate.

The disease pellagra has been in the past associated with the consumption of maize, though it may occur when no maize is taken in the diet. The dermatitis of pellagra is explained as due to an absence of nicotinic acid from the diet and the nervous symptoms as the result of materials in the germ which antagonize the normal action of vitamin A. There is no reason to believe that the consumption of maize induces pellagra so long as the diet is satisfactory as regards its vitamin content.

Maize is prepared for food in many different ways. In Ireland it is made into a sort of porridge, called ***stirabout,*** or, in the more expressive phraseology of America, ***mush.*** In Northern Italy and the South Tyrol it is prepared in a similar way, but with the addition of cheese and other ingredients. Maizemeal is prepared by grinding after removal of the germ and husk. A yellow and a white meal are thus prepared, but there is no difference between them as far as nutritive value is concerned, except that there is a precursor of vitamin A present in the yellow meal.[2] Fine maizemeal is more gritty than wheat flour, but when mixed with the latter its presence can hardly be detected. The comparative cheapness of maize flour is an inducement to millers to adulterate wheat flour with it, and this has been done to some extent in America. Flour so adulterated yields fewer loaves than an equal quantity of pure wheat flour, and the bread produced is moister than wheaten bread, and has a tendency to be sodden. An addition of 10 per cent. of maize flour is calculated to mean a reduction of five loaves on the sack. Owing to the absence of gluten, maizemeal cannot be used to make ordinary bread, but it is often baked into cakes of various sorts. The ***johnny*** (corruption of "journey") ***cakes*** of North America are unleavened, and are made of a rather coarse maizemeal. Similar cakes constitute the ***tortilla*** of South America. The following is the composition of johnny cakes:[1]

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[1] 363 mg. per 100 grammes are phosphorus, of which 58 per cent. is phytate phosphorus.

[2] STEENBOCK, BOUTWELL, and KENT. (1919), *Journ. Biol. Chem.* **41**, xii–xiii.

Water	38·0 per cent.
Protein	8·5 ,,
Fat	2·7 ,,
Carbohydrates	47·3 ,,
Mineral matter	3·5 ,,

On comparing this with the analysis of good white bread, given on p. 322, it will be seen that the comparison is all in favour of maize.

Sometimes the maizemeal is leavened with yeast and subsequently baked in iron vessels. In this form it is known as ***pone,*** while in Ireland baking-powder is used, or the maizemeal is mixed with flour and then converted into loaves. One-third of its weight of good flour is sufficient to enable fine maizemeal to form good loaves. The colour of the bread is always rather dark, however, even if the proportion of wheat flour used is increased to one-half.

Various ***special preparations of maize*** deserve mention. ***Hominy, cerealine,*** and ***samp*** are preparations of broken or split maize of various degrees of fineness. The composition of the first two is as follows:

	Hominy.[2]	Cerealine.[3]
Water	11·9 per cent.	10·6 per cent.
Protein	8·2 ,,	9·4 ,,
Fat	0·6 ,,	1·0 ,,
Carbohydrates	78·9 ,,	78·6 ,,
Mineral matter	0·4 ,,	0·4 ,,

Both preparations are of high nutritive value and admirably adapted for making puddings, etc.

Cornflour is prepared from maize by washing away the protein and fat by means of dilute alkaline solutions, so that little but starch is left. Modern analysis shows but 0·6 per cent. protein (McCance and Widdowson).

These preparations must therefore be regarded simply as agreeable forms of starch, well adapted for food, provided they are taken along with some protein and fat carrier, such as eggs or milk, but by no means to be recommended on economic grounds.

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[1] Analysis by Atwater and Wood.

[2] Analysis by Hutchison.

[3] Analysis by Atwater and Wood.

A special small variety of maize is called in America ***pop-corn.*** When roasted it swells up and ultimately bursts. In this form it is known as "popped pop-corn," and is the basis of various sweets.[1]

COMPOSITION OF POP-CORN

	Raw.	Popped.
Water	10·8 per cent.	4·3 per cent.
Protein	11·2 ,,	10·7 ,,
Fat	5·2 ,,	5·0 ,,
Carbohydrates	71·4 ,,	78·7 ,,
Mineral matter	1·4 ,,	1·3 ,,

It is thus a valuable food.

Corn Flakes [2] consist of cooked maize which has been treated with malt-honey, dried, rolled and baked. It is a nutritious and digestible breakfast food.

Corn on the Cob is a special variety of maize, containing much sugar. It is cooked while still green, and forms a sweet and succulent "vegetable" much esteemed in America. It is making its way into Great Britain.

Maize is not only a highly nutritive cereal from the chemist's point of view, but has the further advantage of being very well utilized in the human body. Experiments show that its carbohydrates are almost completely absorbed, whilst the proteins are only slightly less thoroughly utilized than those of wheat.[3]

Nutritive Value of Maize. Maize must undoubtedly be regarded as a food of great nutritive value. "With a diet of Indian corn bread and pork," says an American writer,[4] "the workmen of this country are capable of enduring the greatest fatigue and performing the greatest amount of physical labour."

Economic Value of Maize. It has been calculated [5] that when maize and wheat are both selling at the same price per bushel one gets the same amount of digestible matter for a given sum in both. In wheat, however, one gets 2½ lb. more protein, and in maize 2½ lb. more carbohydrate. The fuel value in each case is almost precisely the same.

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[1] Analysis by Atwater and Wood.

[2] Battle Creek Sanitarium Company, Ltd.

[3] RUBNER. (1879), *Zeit. f. Biolog.*, **15**, 115. Also see U.S. Dept. of Agriculture, Farmers' Bull. (1907), 298.

[4] U.S. Dept. of Agriculture, Division of Chemistry, Bull. 50, 11.

[5] *ibid.*, 14.

Barley

Barley is a grain grown more for the manufacture of malt and for animal fodder than for direct human nutrition. The whole grain when ground constitutes barleymeal. Scotch barley is the grain stripped of its husk and roughly ground. It is chiefly used as human food, however, in the form of either " pearl " or " patent " barley. The former consists of the whole grain polished after removal of the husk ; the latter is simply pearl barley ground into flour. The following is an analysis of pearl barley by McCance and Widdowson :

Moisture	10·6	per cent.
Protein	8·4	"
Fat	1·7	"
Carbohydrates	81·3	"
Calcium	9·7	mg. per cent.
Iron	0·67	" "
Phosphorus	206·0	" "

It has 120 microgrammes vitamin B_1 (= approx. 40 I.U.) per 100 grammes.

Barley contains but little gluten, in consequence of which its dough is too " heavy " to make good bread. When mixed with half its weight of good wheat flour, however, barleymeal can be converted into good enough loaves.

Writing on the nutritive value of barley in 1872, Letheby said: " Barleymeal is the chief food of a large number of people in the North of Europe and in the South of England, where the labourer is partly paid his wages in meal or grain. It is also used in Wales and Scotland, especially in winter-time, when wheaten bread is dear, and to some extent in Ireland. It is employed by about 90 per cent. of the out-door labouring population of England. At the time of Charles I (1626), according to M'Culloch, it was the usual food of the ordinary sort of people, and as late as the middle of the last century hardly any wheat was used in the Northern counties of England. In Cumberland the principal families used only a small quantity of wheaten bread about Christmas-time. The crust of the everlasting goose-pie, which adorned the table of every county family, was invariably made of barleymeal."

Since this was written barley has been practically displaced by wheat as an ordinary article of diet, and no doubt with considerable nutritive advantage.

As an article of diet in the sick-room, barley finds its chief use as the main ingredient of ***barley-water***, a preparation which contains, however, but very little nutriment, as the following analysis by Wynter Blyth shows.[1]

COMPOSITION OF BARLEY WATER

Water	99·27	per cent.
Fat	0·02	,,
Protein	0·03	,,
Starch	0·39	,,
Sugar	0·05	,,
Inorganic substances	0·03	,,

It is chiefly of value on account of its demulcent properties and makes a pleasant drink with orange or lemon juice.

RYE

Next to wheat, rye is the great bread-making grain of the world. It contains no glutelin which will form gluten with the gliadin and as a result of this the bread derived from rye is moist and dense. An extreme example is the black bread of North Germany.

The composition of the different flours derived from rye varies very considerably with the fineness of milling; but fine rye flour is much poorer in protein than flour of a similar grade produced from wheat.[2]

Fine rye bread is therefore inferior as building material to wheaten bread, but it is somewhat superior in this respect to bread made from maize.

The *digestibility* of fine rye bread is about equal to that of good wheaten bread; but the coarser varieties, especially black bread, are very wasteful foods, 32 per cent. of the protein even in moderately fine rye bread being lost, as compared with 20 per cent. in white bread. In the case of black bread the loss rises to 42 per cent.

Swedish crispbread (***Ryvita***) is prepared from crushed whole rye. An analysis of it by McCance and Widdowson gave the following composition:

Water	5·9	per cent.
Protein	7·4	,,
Fat	2·1	,,
Carbohydrates	86·8	,,
Calcium	40·5	mg. per cent.
Iron	3·73	,, ,,
Phosphorus	295·0	,, ,,

It has a Calorie value of 1696 per lb. or 106 per oz.

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[1] A series of analyses by CORLETTE (*Australasian Med. Gazette*, 1905, **24**, 1) of barley-water prepared from two heaped teaspoonfuls of pearl barley to a pint of water showed that the average amount of starch in the product was 2·03 per cent.

[2] KENT-JONES. (1939), *Modern Cereal Chemistry*, Third Edition, 84 and 85.

RICE

Rice is the poorest of all cereals in protein, fat and mineral matter. On the other hand, it has fully 76 per cent. of starch. The starch has the further advantage of being present in small and easily-digested grains. When boiled, rice swells up and absorbs a large amount of water, while some of its inorganic constituents are lost by solution. It is preferable, therefore, to cook it by steaming.

COMPOSITION OF BOILED RICE[1]

Water	69·9 per cent.
Protein	2·3 ,,
Fat	0·3 ,,
Carbohydrates	29·6 ,,
Calcium	1·3 mg. per cent.
Iron	0·16 ,, ,,
Phosphorus	34·0 ,, ,,

Rice leaves the stomach somewhat slowly, 2½ oz. cooked by boiling (i.e. about two-thirds of a full soup-plate) requiring 3½ hours for its disposal.

On the other hand, rice is ***absorbed*** with very great completeness in the intestine ; indeed, its solid constituents enter the blood almost as completely as those of meat. This is to be attributed to the comparative absence of cellulose. Practically none of the starch is lost, but the waste of protein amounts to 19 per cent.[2] It follows from this that rice is one of the foods which leave the smallest residue in the intestine, and this gives it a considerable value in some cases of disease.

Extensive investigations into the use of rice of different degrees of milling have shown that the digestibility and utilization of rice are always better when the grades of polishing are raised. For example, 97 per cent. of the energy theoretically available was utilized when the rice was fully polished ; when unpolished only 90 per cent.[3] Rice contains about as much phytates as wheat.

The ***nutritive value*** of rice is much impaired by its poverty in protein and fat. Hence it is not adapted to be an exclusive diet, but should be eaten along with other substances rich in these two elements, such as eggs, cheese, or milk. It is interesting to note that in some countries in which rice is largely used as a daily food this is actually done, as in the Italian *Risotto*, the Turkish *Pilaff*, and the Spanish " *Pollo con Riz*." Even as regards carbohydrate it would require about 1 lb. 3 oz. of rice to furnish the daily need of an active man. This would entail the consumption of about 5 lb. of cooked rice daily. It is worth observing, too, that in Eastern countries in which rice takes the place of bread it is eaten in a much drier, and therefore more concentrated, form than it is in Europe, and with the addition of various sauces and condiments to give it flavour and promote its digestion.

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[1] Analysis by McCANCE and WIDDOWSON. (1942), *op. cit.*

[2] KUMAGAWA. (1889), *Virchow's Archiv.*, **116**, 370.

[3] TADASU SAIKI. (1926), *Progress of the Science of Nutrition in Japan*. Publications of the League of Nations III. Health, **3**, 25.

The association of disease with the consumption of large amounts of a highly milled cereal has its classical illustration in highly milled rice. Where polished rice (i.e. rice with the bran, the embryo and the "silverskin" removed) is the staple food, there beri-beri appears. In the very poorest classes in the Far East who cannot afford the highly milled rice, beri-beri is rare ; while beri-beri can be prevented or cured by extracts of rice-bran. There is an intermediate method of processing rice in which it is first parboiled and then the bran removed. In this process some of the antineuritic principles, probably in the main vitamin B^1, migrates into the endosperm—sufficient to prevent the appearance of beri-beri when this product is the main food eaten.

In the poorly nourished parts of the world where rice is the staple food this is of immense importance and as an interim measure the retention of the antineuritic principles in the rice eater should, if possible, be made compulsory. The long-term policy, however, should be to promote a higher standard of living. In countries where rice forms but a small part of the diet, as it does in temperate climates, the amount of milling appears to be of little importance.

MILLET AND BUCKWHEAT

These cereals [1] are not used as human food in this country, although they are by no means of low nutritive value, but stand midway in that respect between wheat on the one hand and rice on the other. Millet is freely consumed in Africa, being the staple diet of the negroes of the Upper Nile, and in some Southern European countries, while in China it is used to make bread. The dhoora (sorgho-grass), or Indian *millet,* is of very similar composition. The following is an analysis of it given by Church :

COMPOSITION OF MILLET

Water	12·2 per cent.
Protein	8·2 ,,
Fat	4·2 ,,
Carbohydrates	70·6 ,,
Cellulose	3·1 ,,
Inorganic substances . . .	1·7 ,,

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[1] Buckwheat is not strictly a cereal, but belongs to the Polygonaceæ. It is considered here for convenience.

Buckwheat is about equal in nutritive value to millet, but contains much more cellulose (10 per cent.). It is usually eaten in the form of a porridge or fritters. In this country, though pleasant, it is hardly ever used as human food, but it is freely consumed in Brittany and Holland, and in some parts of the United States.

The published analyses of buckwheat are somewhat discordant. Four are here given :

COMPOSITION OF BUCKWHEAT

	Church[1] (grain husked).	Leyden[2] (flour).	Atwater and Bryant[3] (flour).	Plimmer[4] (grain).
Water . .	13·4	14·2	13·6	12·6
Protein . .	15·2	9·2	6·4	12·1
Fat . . .	3·4	1·8	1·2	1·9
Carbohydrate .	63·6	73·3	77·6	62·3
Fibre . .	2·1	0·8	0·4	8·9
Inorganic substances	2·3	1·2	0·9	2·2

The Pulses

In this group are included peas, beans, and lentils, and their allies. The edible parts of these resemble the grain of cereals in that they are to be regarded as storehouses of food materials for the young plant. Though regarded as "vegetables," i.e. things to serve with the joint, they are really more valuable as sources of (i) energy and (ii) protein, so that physiologically they belong to this and the next section of this book. They do also supply vitamins of the B complex, iron and some calcium and phosphorus. Their defects are (i) that they contain no fat (with the exception of the soya bean) and (ii) on cooking they take up so much water that they are a bulky food. The proteins in the pulses vary in nature slightly according to their origin. They are mainly globulins being insoluble in water, but water soluble albumins are present. The globulins of pulses are distinguished by having more glutamic acid in their molecules than animal globulins but distinctly less than the main proteins of the cereals. Their content of the sulphur-containing amino-acids is low, while arginine is often high in amount. The proteins of the pulses are very satisfactory sources of phenylalanine, arginine, histidine, and lysine, moderate as regards cystine and tyrosine, while trytophane is present.[5] Their biological value, which is increased by cooking, ranks below that of the cereals.[6]

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[1] *Food :* (1898), Chapman and Hall, London. 93.

[2] Leyden's *Handbuch der Ernährungs Therapie.* (1903), 2nd edn., **1**, 99.

[3] ATWATER and BRYANT. (1906), U.S. Dept. of Agriculture, Bull. 28.

[4] PLIMMER. (1921), *Analyses and Energy values of Foods.*

[5] OSBORNE. (1924), *The Vegetable Proteins.* Longmans, Green & Co.

[6] **BOAS-FIXSEN.** **(1934–5),** ***Nutr. Abstr.*****, 4, 447.**

The pulses are well supplied with carbohydrates, but because of their lack of fat go well with fatty foods (e.g. bacon and beans, pork and pease pudding), and are improved by being served with sauces containing butter, or cooked with oil. They also possess a bitter principle which renders them unpalatable to many persons. Dried peas and beans require prolonged soaking in order to soften their skins. Even haricots, in which the skin is comparatively thin, require about eight hours to soften. The water in which they are soaked should contain a small amount of soda, but not so much as to destroy their vitamin B_1. A negligible amount of protein and sugar is lost by this soaking which, however, has the advantage of removing most of the bitter principle in the seeds. The amount of water taken up is very great. The proportion of water in dried haricot beans, for example, rises as the result of soaking and boiling from 14 per cent. up to 73 per cent., and in the case of peas the increase is from 9·7 up to 86·9 per cent.[1] This increase in water entails a corresponding increase in the weight and bulk of the food, and must always be taken into account when comparing the relative nutritive values of the pulses and meat.

The pulses are ***not readily digested*** by the stomach. As Galen said: "They are harder to digest than other foods and give bad dreams." This is no doubt partly owing to their bulkiness when cooked. Thus after 5⅓ oz. (150 grammes) of lentils in the form of a mash, or about a soup-plateful, had been eaten the stomach was not completely empty in 4 hours, and after 200 grammes of peas in a similar form in 4¼ hours. An equal weight of French beans (*haricots verts*) remained rather longer even than that.

If properly prepared, the pulses are ***absorbed*** in the intestine very thoroughly. Thus the protein of pea or lentil flour is all taken up except about 8 or 9 per cent.[2] when 200 grammes (7 oz.) are given daily. Even when the amount given was as much as 600 grammes (21½ oz.) the loss was only as follows:[3]

Dry substance	9·1 per cent.
Protein	17·5 ,,
Carbohydrate	3·6 ,,
Inorganic material . . .	32·5 ,,

This shows that the protein of the pulses, if given in a state of fine division, is capable of very good absorption. On the other hand, the loss is very much greater if the food is not given in a state of fine division. It was found, for example, that if the lentils were simply boiled soft and taken along with broth, the loss of protein rose to 40 per cent. It will be noted that there was a small loss of carbohydrate even on pea flour. The amount of it, however, is less than from potatoes or carrots, but more than that from white bread.

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[1] Analyses by Williams. (1892), *Journ. of Chem. Soc.*, **61**, 226. 1 oz. of peas take up approximately 2 oz. of water. McCance and Widdowson. (1942), *Med. Res. Council Report*, No. 235.

[2] Strümpell. (1876), *Deut. Archiv. f. Klin. Med.*, **17**, 108.

[3] Rubner. (1880), *Zeit. f. Biolog.*, **16**, 119.

Extensive investigations on the absorption of different forms of legumes have been made in America.[1] They showed an average absorption of 80 per cent. of the protein and 97 per cent. of the carbohydrates. These results are very favourable when it is remembered that the legumes constituted the major part of the diet in the subjects studied.

The nutritive value of the pulses is undoubtedly high. They yield about 1500 Calories per lb. (94 per oz.), and they have considerable value as sources of protein, although the comparative deficiency of the protein in sulphur containing amino-acids probably lessens its value as a source of building material. It would require about 400 grammes (14 oz.) of pea flour to supply the amount of protein required daily for an active man. Suppose this were to be given in the form of pea soup. A good thick soup would contain 16 grammes—a level tablespoonful—in each plate. The protein value of this would be equal to less than an ounce of meat. Twenty-five platefuls of such a soup, then, would require to be taken in the day. By making the soup with milk instead of water—an excellent plan—the amount of protein in it would be trebled, and eight platefuls would suffice.

The 400 grammes of pea flour would hardly, however, contain as much carbohydrate as is required, and would be very deficient in fat. These deficiencies would have to be made good by the addition of some other articles to the diet, or by increasing the amount of pea flour consumed. As a matter of fact, it has been found that when the quantity of peas eaten amounts to 960 grammes (34½ oz.) in the 24 hours, all the demands of nutrition as regards Calories and protein are satisfied;[2] but it is very doubtful whether anyone could go on consuming this quantity for any length of time. I comes then to this, that, while the pulses are most valuable sources of Calories and protein, they are not adapted to be the exclusive diet of health. As a cheap and efficient method of supplementing the deficiency of nitrogen in a purely vegetable diet, however, their use is strongly to be recommended, and it is a pity that

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[1] *Studies on the Digestibility and Nutritive Value of Legumes.* (1907), U.S. Dept. of Agriculture, Bull. 187.

[2] RUBNER, *loc. cit.*

COMPOSITION OF PULSES[1]

	Protein.	Available Carbo-hydrate	Unavailable Carbo-hydrate.	Calories	Milligrammes per 100 grammes.							
					Na.	K.	Ca.	Mg.	Fe.	Cu.	P.	S.
		Per cent	Per cent.	Per 100 grammes								
Beans, butter, raw .	19·2	49·8	24·5	266	61·5	1700	84·8	164·0	5·92	1·22	318·0	109
„ „ boiled	7·1	17·1	5·1	93	16·2	398	18·7	33·3	1·67	0·16	86·5	47·2
„ haricot, raw .	21·4	45·5	28·8	258	43·2	1160	180·0	183·0	6·65	0·61	309·0	166
„ „ boiled	6·6	16·6	7·4	89	15·0	320	64·5	44·5	2·50	0·14	122·0	46·3
„ runner, raw .	1·1	2·9	3·0	15	6·5	276	33·3	23·0	0·74	0·09	25·9	14·1
„ „ boiled	0·8	0·9	3·0	7	3·3	87	25·6	12·5	0·59	0·03	10·7	9·5
Lentils, raw . . .	23·8	53·2	17·4	297	36·0	673	38·6	76·5	7·62	0·58	242·0	122
„ boiled . .	6·8	18·3	2·4	96	9·4	217	10·5	20·7	2·20	0·27	80·0	37·3
Peas, raw, fresh . .	5·8	10·6	5·2	64	0·5	342	15·1	30·2	1·88	0·23	104·0	50·0
„ boiled, fresh .	5·0	7·7	5·2	49	Tr.	174	12·6	21·4	1·22	0·15	83·3	43·5
„ dried, raw . .	21·5	50·0	21·3	275	37·9	985	60·8	116·0	4·73	0·49	303·0	129
„ „ boiled .	6·9	19·1	4·8	100	12·6	267	24·4	30·3	1·44	0·17	113·0	39
„ split, dried, raw	22·1	56·6	17·2	303	38·3	910	33·0	125·0	5·40	0·58	268·0	166
„ „ dried, boiled	8·3	21·9	5·1	116	14·2	269	10·8	30·2	1·74	0·25	122·0	45·7
„ tinned . . .	5·9	16·5	4·4	86	(260)	201	25·7	24·4	1·87	0·21	169·0	43·9

[1] McCANCE and WIDDOWSON. (1942), *Med. Res. Council Special Report*, No. 235.

they are not more largely taken advantage of by those to whom economy is of importance, for unquestionably the pulses are amongst the cheapest foods, and a given sum will yield more protein, if invested in them, than in any other way. It remains to add a few words about the individual members of the pulse group. Their chemical composition is shown in the table on page 345.

The ***garden pea*** (Pisum sativum) is eaten either fresh (green peas) or dried. Green peas cooked in the usual way contain about 8 per cent. of carbohydrate, of which a considerable proportion is sugar. Of ***beans*** there are several edible varieties. The French or kidney bean (Phaseolus vulgaris) is eaten either in the young state along with the pod (*haricots verts*), or the seeds are consumed alone either fresh or after drying (*haricots blancs*). The amount of cellulose in the pod causes it to be digested and absorbed with difficulty, and on that account it is a wasteful form of food. Allied to the French bean is the scarlet runner (Phaseolus multiflorus), the dried seed of which when stewed constitutes "Turkish beans." The ***broad*** or ***Windsor bean*** (Faba vulgaris) is eaten either in the fresh or dry state. It is a frequent cause of allergy when eaten in large amounts.[1] A coarser variety of the same plant is the horse or field bean. It is not usually consumed as human food.

The ***Lentil*** (Lens esculenta) is even richer in protein than either the pea or the bean, and, as a rule, the smaller varieties of it are richer in that constituent than the larger. Egyptian lentils are amongst the best. Lentils contain little sulphur, and are more digestible and less apt to cause flatulence than either peas or beans. The ash of the Egyptian lentil is particularly rich in iron.

The ***Soya Bean*** (*Glycine hispida*) is one of the pulses which has sprung into remarkable prominence in this country and elsewhere during the second World War, though it has been used for many centuries—as early as 3000 B.C.—in China. Its present vogue is due partly to the belief that it formed the basis of the iron rations of Hitler's Blitzkrieg soldiers and partly to the activities of the Ford automobile company. According to Sir John Russell of Rothamstead it cannot be satisfactorily grown in the uncertain climate of Great Britain, even if the rapidly ripening varieties developed for cultivation in Manitoba be utilized. It needs a hot dry summer. Its original source is Manchuria, but it is now successfully grown in central Europe, the U.S.A. and Canada and in the Dutch East Indies.

It is remarkable among the pulses in its high content of protein (29 to 50 per cent.), its fat (13·5 to 24 per cent.) and the replacement of starch by dextrins (4·65 to 8·97 per cent.) and by sugars 5·65–9·46 per cent.). On account of the absence of starch it has been mistakenly used as a substitute for bread in diabetes.

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[1] *Lancet.* (1941), 2, 164.

In China and Japan it is extensively eaten in the form of soya cheese and as various sauces and pastes, all of which are rich in protein and therefore fitted to supplement the deficiencies of rice. It has also been used for centuries by millions of people in the Far East in place of cow's milk, and it can, in part, replace milk in diet of infants.[1] Aykroyd [2] in experiments on the growth of mission-school children in India has found that soya bean is disappointing. Addition of it to the standard diet caused no increase of growth rate, whereas skimmed milk powders produced a marked improvement. Consequently the claims made for the nutritional advantages of a soya bean diet must be discounted.

There is a preparation of soya bean on the market from which the unpleasant beany flavour has been removed. This is "Soyolk." [3] It is intended for mixture with ordinary flour in the making of scones, buns, pastry and bread, for which purpose it is excellent, giving a brown glazed appearance which is much prized. It has 44 per cent. of protein, 20·6 per cent. of fat and 25 per cent. of carbohydrates. Its percentage of calcium (0·3) is more than double that of milk.

Soya bean has for long been used as a filling for sausages, pre-eminently so in this country during the later years of the second World War. Dried soya bean milk forms the basis of a food beverage called Vitone.

The ***Peanut*** (Arachis hypogæa), although botanically one of the pulses, really resembles more closely the true nuts. Like these, it is rich in proteins and fat, containing about 25 per cent. protein and 48 to 54 per cent. fat. Its carbohydrates are only 11 per cent. From the distribution of the amino-acids in the two main proteins, arachin and conarachin, they should have a good biological value.[4] The fat expressed from the nut is used in the manufacture of margarine.

Peanuts are not an important item of diet in this country, though they are eaten largely in the United States and Canada, either roasted or in the form of peanut butter, a comestible which has made its way into Great Britain during recent years. Agriculturally the pea-nut crop is becoming one of the most important crops of the world.

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[1] Rittinger. (1935), *Journ. of Ped.*, 6, 517; Mackay. (1940), *Arch. Dis. Childh.*, 15.

[2] Aykroyd and Krishnan. (1937), *Ind. J. med. Res.*, 24, 1093.

[3] The Soya Flour Manufacturing Co., Ltd., Rickmansworth.

[4] Traill. (1945), *Chem. and Ind.*, 58.

Composition of Nuts (Edible Portion) [1]

	Grammes per 100 grammes.			Milligrammes per 100 grammes.									Vitamins. I.U. per 100 grammes.			Calories per oz.
	Protein.	Fat.	Available Carbohydrate.	Na.	K.	Ca.	Mg.	Fe.	Cu.	P.	Available P.	Cl.	A.	B_1.	C.	
Almonds .	20·5	53·5	3·9	5·8	856	247	257	4·23	0·14	442	78	1·7	—	80	0–386	151
Barcelona	12·9	64·0	4·7	2·5	935	170	202	2·97	0·96	299	49	33·5	—	—	—	183
Brazil . .	13·8	61·5	3·7	1·5	760	176	411	2·82	1·10	592	82	61·0	—	—	—	177
Chestnut .	2·3	2·7	32·9	10·9	497	46	33	0·89	0·23	74	65	15·0	—	90	646	47
Cob nut .	9·0	36·0	6·1	1·4	345	44	56	1·06	0·21	229	59	5·9	—	200	300	109
Coco-nut .	3·8	36·0	3·3	16·5	436	13	52	2·08	0·32	94	19	114·0	—	trace	16	100
Peanut .	28·1	49·0	7·7	5·6	680	61	181	2·04	0·27	365	145	6·8	63	100	—	166
Walnut .	12·5	51·5	4·5	2·7	687	61	131	2·35	0·31	510	298	23·0	—	150	600	151

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[1] Chemical Analyses by McCance and Widdowson. (1942), *Med. Res. Council Report*, No. 235. Vitamin figures from Fixsen and Roscoe. (1937–8), *Nut. Abs. and Rev.*, 7, 823.

Nuts

From their analyses given on p. 348 it appears that nuts are a valuable form of diet. With the exception of the chestnut they have a high Calorie value, approaching or exceeding that of cheese and bacon ; a high protein value, with the exception of chestnut, cob nuts and coco-nuts ; the calcium values of almonds, barcelonas and brazils are high but partly offset by their phytate phorphorus and they unexpectedly possess vitamin C, though this may have been over-estimated.

But in dietetics, at any rate in the British Isles, their contribution to the diet is almost negligible. This may be due to lack of fashion-demand except among vegetarians, to the large amount of waste as purchased (except in the chestnut) and to their reputed indigestibility.

This indigestibility is due in part to their richness in fat and to their compact framework of cellulose. By thorough mastication this difficulty can be overcome to some extent, but is still more efficiently dealt with by artificial grinding and cooking. Various preparations are on the market and can be found in shops which supply vegetarians. The fibrous nature of nuts irritates the pharynx and consumptives and others with respiratory diseases should avoid them.

A few experiments have been made on the ***absorbability*** of nuts. In one which was carried out in America,[1] and in which the subject of experiment lived solely on a diet of fruit and nuts, it was found that 82·5 per cent. of the protein,[2] 86·9 per cent. of the fat, and 96 per cent. of the non-nitrogenous matters were absorbed. This result compares favourably with the absorption of an ordinary mixed diet except that it reveals a rather greater waste of protein, and shows that it is quite possible, for long periods even, to supply the requisite protein and energy from a diet made up of selected fruits and nuts. Fine division greatly aids their digestibility.

Of all the members of this class of foods, the ***chestnut*** is probably of the greatest general value as an article of diet. It is peculiar amongst nuts in containing a high proportion of carbohydrates along with a fair amount of protein and fat, as is shown on

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[1] *Nutrition Investigations among Fruitarians and Chinese*, U.S. Dept. of Agriculture. (1901), Bull. No. 107. For later experiments, which, however, yielded substantially the same results, see *Nuts and their Uses as Foods.* (1908), Farmers' Bull. No. 332, also CAJORI. (1918), *Journ. Home Econ.*, **10**, 304.

[2] So far as it has been investigated, the biological value of nut proteins is low, even below that of legumes. BOAS-FIXSEN. (1934–5), *Nut. Abs.*, **4**, 447.

p. 348. Roasted chestnuts have 40 per cent. water. Those cooked by boiling have 72 per cent.

An economic point in favour of chestnuts also is the fact that a given area of ground produces perhaps the maximum amount of human food when planted with chestnut-trees.

The great value of the chestnut has been fully recognized by the poorer peasantry of Central France. During the autumn and winter they often make two meals a day from it alone. The nuts are prepared by removing the outside shell, blanching, and then steaming; salt and milk are added when they are eaten. Sometimes they are ground after blanching, and the meal made into flat cakes.

The ***almond*** is another very valuable form of nut, being specially noteworthy for the large amount of nitrogenous matter which it contains. It has the further advantage of being compact and portable. " No man," it has been said, " need starve on a journey who can fill his waistcoat pocket with almonds."

From the graphic representation of a typical nut, the walnut, and from the tables it will be observed that fatty matter predominates very largely in the composition of nuts, with the exception of the chestnut. No other vegetable substance is so rich in fats. Advantage has been taken of this to prepare from nuts various fatty preparations which are used as cheap and efficient ***substitutes for ordinary butter*** in the kitchen. Advertisements of these will be found in the vegetarian magazines. There is every reason to believe that these are equal in fuel value to ordinary butter, whilst they are decidedly more economical. The fat of the coco-nut is used in the manufacture of margarine.

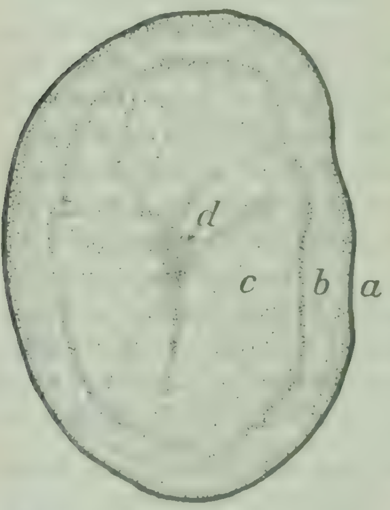

FIG. 16.—CROSS SECTION OF A POTATO.

a, Skin; *b*, Fibro-vascular layer; *c* Outer zone of flesh; *d*, Central core'.

The Potato

Next to maize the potato is the most valuable food contributed by the western hemisphere to the Old World. In fact to Europe it is the most important contribution made, and the varieties evolved from the original source are legion. The potato is the swollen underground stem of the potato plant in which it stores its nutriment for use of the young plant.

The potato originated probably in Peru or Bolivia and was first cultivated, mainly as a curiosity, in Europe near Seville in 1572. Its introduction into England in 1586 is attributed to Sir Walter Raleigh.[1] To-day scientific agriculturists have returned to Peru to obtain material for breeding experiments and so evolve potatoes resistant to disease and frost. Although introduced so long ago, it took two centuries for its use to become at all common. Ireland was the country where it first became popular, and such an exclusive hold had it in the dietary of the Irish that potato disease, rampant in the years 1845 to 1847, caused famine in that country and led to the repeal of the Corn Laws in Great Britain.

If a raw potato be cut across with a sharp knife, three distinct ***layers*** can easily be made out (Fig. 16). These are (1) the thin outer skin. (2) A broader layer inside the skin called the "fibro-vascular layer." It contains a small amount of pigment, and turns green when exposed to the light. This was supposed, on inadequate evidence, to make the potato poisonous. (3) The flesh of the potato, which makes up the rest of its bulk. On more careful inspection this is seen to be divided into a central core and an outer zone which surrounds it.

These different layers form the following proportions of the whole potato:

1. Outer rind . . . . = 2½ per cent.
2. Fibro-vascular layer . . = 8½ „
3. Flesh . . . . . . = 89 „

The importance of recognizing them is due to the fact that they differ somewhat in chemical composition, as is shown in the following table:[2]

COMPOSITION OF A POTATO

	Water.	Nitrogen.		Fat.	Carbo-hydrate.	Ash.
		As Protein.	Total.			
Outer rind . .	80·1	0·25	0·43	0·8	14·6	1·8
Fibro-vascular layer	83·2	0·24	0·36	0·1	13·3	1·1
Flesh . . .	81·1	0·18	0·32	0·1	16·0	0·8
Whole potato . .	81·3	0·19	0·32	0·1	15·7	0·9

The fibro-vascular layer is seen to be richer in inorganic matter and protein than the flesh, and in peeling it off with the rind we lose these ingredients.

If the flesh of the potato is squeezed it can be separated into a solid part and a juice. The former consists mainly of starch; it has only 15 per cent. of the nitrogenous matter. The juice consists of water holding in solution nitrogenous matter and salts. It contains fully 85 per cent. of the total amount of nitrogenous matter present in the potato.

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[1] LINNÉ. (1939), *Nature*, **143**, 12. In a review of Salaman's work.

[2] See U.S. Dept. of Agriculture. (1897), Bull. 43.

It must be clearly realized that by no means all of this nitrogenous matter is present in the form of protein. Of the total amount of nitrogen in a potato, only 37 to 64 per cent. is contained in proteins, the remainder being simple nitrogenous bodies such as asparagine, glutamine, arginine and choline.[1] The failure to recognize this fact has led people to assume that the whole of the nitrogen of the potato represents protein, and to overrate the value of potatoes as tissue-building food.

The ***richness of the potato in starch*** is its most striking chemical characteristic, and causes it to be one of the chief commercial sources of that substance. Dextrin and " British arrowroot " and many other things are prepared from it. The starch grain of the potato is of specially large size, but unless cooked it is not easily digested and absorbed by the body, and it causes much flatulence.[2] Owing to their readiness to undergo fermentation potatoes should be avoided in conditions such as dilatation of the stomach.

The most important inorganic ingredients of potatoes are potassium salts, and potatoes are one of the chief sources from which we obtain our supply of these salts. Part of the potassium is united with citric acid. Potatoes, like all tubers, may have their composition modified by the ***mode in which they are cooked.***

Plain boiling removes some nitrogenous and inorganic materials but leaves the starch practically unaltered, as the following figures show : [3]

	Gms. per 100 grammes.		Mg. per 100 grammes.							
	Protein.	Available Carbohydrate.	Na.	K.	Ca.	Mg.	Fe.	Cu.	P.	Cl.
Potatoes, old, raw . .	2·1	20·8	6·5	568	7·7	24·2	0·75	0·15	40·3	78·5
,, old, peeled and boiled 30 mins.	1·4	19·7	3·4	325	4·3	15·0	0·48	0·11	29·0	40·7

As we eat potatoes mainly for their carbohydrate and not for their nitrogen, potassium and chlorides, the loss in these materials, which can be largely obviated by boiling in their jackets, does not matter. There is a loss of one-quarter to one-third of vitamin C on boiling [1] and of one-quarter of the vitamin B_1.[2] However, 4¼ to 5¾ oz. of boiled new potatoes give 30 milligrammes of ascorbic acid—a day's ration—so that the loss is not very important. Boiled old potatoes yield 0·3 I.U. of vitamin B_1 per gramme. More would be conserved were they boiled in their jackets.

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[1] NEUBERGER and SANGER. (1942), *Biochem. Journ.*, 36, 665.

[2] LANGWORTHY and MERRILL. (1924), U.S. Dept. of Agriculture, Bull. 1213.

[3] MCCANCE and WIDDOWSON. (1942), *Med. Res. Council Rep.* No. 235.

Mention of vitamin C recalls the fact that shortage of potatoes due to disease or other causes is followed invariably by outbreaks of scurvy, so that it is probable that the potato is the main source of vitamin C in the British diet. As the majority of potatoes contain anything from 10 to 53 milligrammes of vitamin C per 100 grammes (3½ oz.), and the average person consumes up to 8 oz. per day it will be seen that, even with the loss that occurs on boiling, a large quantity of vitamin C will be taken every day. From March onwards the old potato contains only 7 milligrammes per 100 grammes.[3] Steaming, keeping them warm for a long time, reheating them, cooking them in a haybox, i.e. "fireless cooker," result in much greater destruction, so that no one living much in hotels or public institutions or feeding in restaurants should trust the cooked potato as an adequate source of vitamin C.

The composition of fried and roast potatoes is as follows: [4]

Gms. per 100 g.				mg. per 100 g.							
	Protein.	Fat.	Available Carbohydrate.	Na.	K.	Ca.	Mg.	Fe.	Cu.	P.	Cl.
Fried . .	3·8	9·0	37·3	mg. 11·7	1020	13·8	43·3	1·35	0·27	72·2	140·0
Roast .	2·8	1·0	27·3	8·6	745	10·1	32·0	0·99	0·20	53·0	103·0

The *digestibility of potatoes* in the mouth and stomach depends largely on the form in which they are eaten. They are less digestible when eaten as lumps than in a purée; and "mealy" potatoes are more digestible than "waxy," or new potatoes.

Two medium-sized potatoes (weighing together 5⅓ oz.) when boiled and eaten in the usual way remain for about 2 to 2½ hours in the stomach—that is, a shorter time than a similar weight of bread.

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[1] Olliver. (1936), *Chem. and Ind.*, **55**, 153T.

[2] Baker and Wright. (1935), *Biochem. Journ.*, **29**, 1802.

[3] *The Nutritive Values of War-time Foods.* (1945.)

[4] McCance and Widdowson. (1942), *Med. Res. Council Rep.* No. 235.

In the intestine potatoes are, on the whole, very well ***absorbed.*** This is owing to the fact that they contain much starch and little cellulose. Even when the quantity consumed daily amounts to 3½ lb., 92½ per cent. of the starch and 70 per cent. of the total nitrogen enters the blood.

Potatoes are, however, by no means suited to constitute the sole, or even the staple, diet of man. They are much too bulky, and contain too little protein in proportion to their starch. As a matter of fact, however, Rubner has found that 6½ lb. of potatoes are enough to furnish 3003 Calories of energy and to prevent any loss of bodily protein. This is probably to be explained by the relatively enormous quantity of carbohydrates (i.e. protein-sparers) which such a diet contains.[1] Hindhede obtained even better results, and is a strong advocate of the potato as an efficient and economical source even of protein.[2]

Even granting that 6 lb. of potatoes per day is sufficient to supply fully all the needs of the body, it must be evident that this quantity is still unduly bulky, weighing as it does about twice as much as an ordinary mixed diet. The result of its continued use would be an undue burdening of the stomach and bowels, culminating in dilatation, if not disease, of these organs. The so-called "potato belly" of the Irish peasant is an example of such a result.

As regards ***economic value,*** potatoes must be regarded as a cheap, but by no means the cheapest, kind of food. Thus, when potatoes are selling at 1*d.* and bread at 1½*d.* per lb. the former are two or three times dearer than the latter. From the point of view of national economy, however, potatoes are undoubtedly a cheap food. Thus, Boussingault found that a given piece of land produces:

	Wheat.	Rye.	Peas.	Potatoes.
Protein . . .	510	440	560	950
Starch . . .	1590	1196	780	6840
Ash	90	62	60	323

Whenever there is an emergency need for more home-grown Calories, as there has been in this country during the second World War, correspondents write to *The Times* urging the pre-eminence of the ***Jerusalem artichoke***, over the potato, pointing out that this tuber produces, weight for weight, more return per acre than the potato. This is true. But when investigated dietetically the case for the artichoke breaks down. The carbohydrate storage product of the tuber is inulin mainly, and as such indigestible. Even assuming that half the carbohydrate is available the artichoke contains but 3·2 per cent. against the potato's 20 per cent. One pound of boiled artichokes yield 86 Calories to the body, whereas potatoes yield at least 360. The suggestion of replacing potatoes by artichokes is dietetically ludicrous. Besides that they are intensely disliked in the kitchen and on the table. It must be again emphasized that, despite their other valuable characteristics, potatoes are taken mainly for their Calories, and indeed are often associated with the cereals as the main sources of Calories.[1]

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[1] There is some evidence that the nitrogenous constituents of potatoes are nearly twice as valuable for the repair of tissues as those of bread.

[2] (1926), *The Practitioner*, 116, 249.

Allied to the potato, though not much eaten in this country, are the sweet potato and the yam.

The ***Sweet Potato*** (Ipomœa batatas) is cultivated in hot countries, and is largely eaten in the United States. It used to be eaten in England before the present potato was introduced, and it is to it that Shakespeare refers when he makes Falstaff say, " Let the sky rain potatoes ! " It contains carotene, the precursor of vitamin A.

The ***Yam*** is the tuber of a tropical plant, Dioscorea, and is much larger than the potato, but resembles it in taste.

The composition of the sweet potato and yam is as follows :

	Protein.	Fat.	Carbohydrate.	Ash.
Sweet Potato	1·6	0·5	22·5	0·7
Yam	2·2	0·5	15·3	1·5

They are fully equal to the ordinary potato in nutritive value.

Arrowroot, Sago, and Tapioca

These substances, which consist of little more than starch and dextrins, and are used in this country only as a basis for puddings, etc., must be considered under the heading of foods taken for Calories, because in some parts of the world they bulk largely in the diet and are used where we should use cereals.

Modern analyses give the following compositions :

	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Phosphorus.	Calories per oz.	Vitamins A, B_1, C.
				mg.	mg.	mg.		
Arrowroot.	0·4	0·1	90·6	7·0	1·95	27	97	0
Sago	0·3	0·2	94·0	9·8	1·18	29	101	0
Tapioca	0·4	0·1	95·0	8·2	0·32	30	102	0

It will be seen from this table that these foods are almost useless except for Calories. Of these they give as much as cereals and, indeed, are usually classified with the cereals, though this is unwise.

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[1] Le Gros Clark. (1943), *Discovery*, July.

It is not to be expected that nations who live largely on any one of these foods could attain the physique of those living on rice or other cereals.

Arrowroot is obtained from the rhizome of a West Indian plant (Maranta arundinacea). The roots are mashed up, mixed with water, and the starch allowed to settle. When dried, it constitutes ordinary arrowroot. The superiority of ***Bermuda arrowroot*** to the other varieties is due to greater care in manufacture. The starch, having been washed away from the mashed roots and strained through muslin, is allowed to settle, and is subsequently dried in flat copper pans covered with gauze. When dry, it is packed by means of German-silver shovels into new barrels lined with paper stuck in with arrowroot paste. All these precautions are necessary to prevent the arrowroot from becoming contaminated, as it is so apt to be, by foreign flavours. For a similar reason it is exported on deck under covers, lest it may be affected by effluvia from the cargo in the hold.

Arrowroot contains 11 per cent. of water, and 90 per cent. of starch, dextrins and sugar estimated as glucose, along with only about 0·4 per cent. of protein and 0·7 per cent. of ash.

The ***digestibility of arrowroot*** and its allies in the stomach is probably high, and their absorption in the intestine is exceedingly complete. This gives them a special value in the treatment of diarrhœa.

Sago is derived from the pith of the sago palm. The trees are felled, split, and the starch washed out. It is then dried, and converted into pearl sago by granulating. One tree should yield about 500 pounds of sago. Commercial sago contains 94 per cent. of starch.

Tapioca is derived from the roots of South American cassavas, plants belonging to the Spurge order (Euphorbiaceæ). Curiously enough, one of these—the bitter cassava (Manihot utilissima)—contains a milky juice mixed with the starch in which there is a good deal of that dangerous poison hydrocyanic (prussic) acid.[1] In preparing tapioca the juice is washed away from the grated root and the starch allowed to settle. It is then collected and dried on hot metal plates. The process of drying has the effect of rupturing most of the starch grains. Tapioca as found in the market contains about 11 per cent. of water and 85·5 per cent. of carbohydrate, and has a fuel value of 1578 Calories per pound. Pure starch contains only 2 per cent. of water, and a pound of it furnishes 1825 Calories, so that weight for weight pure starch gives considerably more Calories than tapioca.

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[1] This gives an amusing counter to food cranks who say that we should eat the foods nature supplies us in their natural condition.

Tapioca remains longer than might be expected in the stomach. Forty grammes of it in the form of a thick gruel (about a soup-plateful) had not entirely left the stomach until after the lapse of two hours and forty minutes (Penzoldt). There is reason to believe that it is absorbed very completely in the intestine.

As regards the ***nutritive value*** of all these preparations, it must be remembered that they are simply agreeable forms of starch ; in other words, they consist almost entirely of carbohydrate, and should therefore not be eaten alone, but along with substances rich in protein, fat and vitamins. Eggs and milk are typical examples of such substances, and accordingly one finds that people have made puddings of arrowroot, sago, or tapioca along with milk and eggs, before anything was known of the chemical constituents of the diet. Tapioca pudding has something like the following composition :[1]

Water	71·7	per cent.
Protein	3·2	„
Fat	3·8	„
Carbohydrates	21·4	„
Calcium	0·116	„
Iron	0·0098	„
Phosphorus	0·095	„

and has a fuel value of about 128 Calories per serving (3½ oz.). It must be regarded as a highly nutritious food.

A cupful of ***water-arrowroot*** contains only about 2 grammes of starch. It would furnish to the body about 9 Calories of fuel value, while even an invalid requires about 2000 Calories daily.

When one considers the ***economy*** of these different preparations, one may say that sago and tapioca are worth the price paid for them, while the better qualities of arrowroot certainly are not. Starch at 4½*d.* a pound is really rather dearer than tapioca at 3½*d.* or sago at 3*d.*, even although it contains 10 per cent. more nutriment. Apart altogether from that, also, one cannot eat pure starch, whereas the same chemical substance in the form of tapioca or sago is quite agreeable. On the other hand, Bermuda arrowroot at 7*s.* 3*d.* the pound is a purely luxury article. The cheaper kinds at 9½*d.* are quite as nutritious, and there can be no physiological objection to the substitution for a genuine article of the so-called ***Farina*** or ***English arrowroot***, prepared from the starch of maize or potatoes, at 3½*d.* per lb. Even although it requires more of these to make a jelly than of the genuine arrowroot, yet this difference is far more than made up for by the difference in price.

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[1] McCance and Widdowson. (1942), *Med. Res. Counc. Spec. Rep.* 235. The protein, fat, and calcium are added by the milk.

CHAPTER XIII

FOODS TAKEN CHIEFLY FOR PROTEIN

As has already been said dietitians are accustomed to divide proteins into two classes. The first class are those whose distribution of amino-acids is similar to that in human proteins, while the second class are those which are deficient in such amino-acids as lysine, methionine, phenylalanine and tryptophane.[1] The two classes approximately coincide with animal and vegetable proteins, though gelatin is an exception among animal proteins and potato and rice proteins are exceptions among vegetable proteins. So that to the dietitian cheese, eggs, fish, meat and milk are the foods of greatest value in body building, whereas cereal and pulse proteins are of secondary value for that purpose. Moreover the concentration of proteins is high in foods of animal origin, with the exception of milk, running from 10 to 35 per cent. of the raw food, whereas cereal and pulse proteins are usually under 10 per cent. if we take the values of cooked foods. Cooking concentrates the proteins in animal foods but decreases concentration in vegetable foods. Consequently animal foods are a concentrated source of body-building material, whereas vegetable foods have their second-rate proteins considerably diluted with water, starch, cellulose, etc. We have already discussed the proteins of cereals and pulses in the section devoted to foods taken mainly for energy purposes, and it is now necessary to discuss the values of the animal foods.

Pre-eminent among foods containing proteins of high biological value—" first-class proteins "—are eggs, milk and milk products, and these will be discussed first. All estimates of their biological value put egg and milk proteins high.[2] They were developed for body-building purposes for mammal and birds and though the biological value of their proteins may be best for cows (for example) and ducks and hens, they also have a very high value for human beings.

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[1] For the importance of methionine in reconstituting animal proteins see PETERS. (1945), *Lancet*, **1**, 266.

[2] BOAS-FIXSEN. (1935), *Nut. Abst. and Rev.*, **4**, 447.

EGGS

An egg is an undeveloped chick. This may sound a truism, but it is the key to the right understanding of the value of eggs as food. For if the chick is developed from the egg without the aid of any external agency save heat and correct gaseous environment as to composition and pressure, it follows that the egg must contain within itself all the building material necessary for the making of the chick, along with such a supply of nutriment as the latter requires until it is ready to be hatched. Kingsley's comparison of them with treasure houses is not inapt though unhumorous—and unbiological.[1]

In chemical language, they must contain much protein and inorganic matter (especially calcium, phosphorus, and iron), for these are the only materials out of which " blood and bone " can be built. They are likely, also, to contain fat, for that is the most compact form in which nutriment for the young chick can be stored. And, as a matter of fact, it is practically of these constituents that an egg consists. Carbohydrate[2] it need not contain, for the chief use of carbohydrate is, as we have seen, to serve as a source of muscular energy ; and in the narrow confines of an eggshell, muscular movement is restricted.

Passing on to details, it may be said that a hen's egg of average size weighs about 50 grammes (nearly 2 oz.), the weight being distributed as follows :

Shell	12 per cent., or	6	grammes.
White . . .	58 „ „	29	„
Yolk	30 „ „	15	„

The ***shell*** consists almost entirely of carbonate of lime. As the process of hatching goes on it loses some 9 per cent. of its weight by absorption, and one might think that it was used as a storehouse of lime which is drawn upon for the formation of the bones. Modern research bears out this assumption.

The protein of ***white of egg*** is called " egg albumin." It is an error, however, to regard it as a single substance. It consists of a mixture of different proteins, some of which are of a compound nature, and contain a carbohydrate group in their molecule.[1] The white contains 0·4 to 0·5 milligramme riboflavine per 100 grammes and also avidin, a substance which renders biotin, a member of the B complex of vitamins, unavailable.[2]

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[1] " Treasure houses, wherein lie,
Locked by angels' alchemy,
Milk and hair and blood and bone."

[2] There is a small amount of free carbohydrate material in eggs variously estimated at 40 to 230 milligrammes per egg (NEEDHAM. (1931), *Chemical Embryology*, 282). In addition there is glucosamine, which yields glucose on hydrolysis, in ovalbumin and ovomucoid (*ibid.*, 277).

The ***yolk*** is the chief storehouse of nutriment for the young chick, and consequently has a very different composition from the white. It contains much less water and more solid matters, amongst the latter being a large proportion of fat. The general composition of the white and yolk is contrasted in the following table (König),[3] and graphically illustrated in the accompanying diagrams (Figs. 17 and 18):

COMPOSITION OF EGG

	Water.	Protein.	Fat.	Other Non-nitrogenous Matter.	Mineral Elements.
White .	85·7	12·6	0·25	—	0·59
Yolk .	50·9	16·2	31·75	0·13	1·09

One can see at a glance that the yolk of the egg is relatively its most nourishing part. The complexity of the composition of the yolk is shown by the following detailed analysis of its constituents:[4]

COMPOSITION OF YOLK OF EGG

Water	47	to 54	per cent.
Proteins	15	,, 17·5	,,
Fat	21	,, 33	,,
Mineral element . . .	0·5	,, 2·0	,,
Extractives	0·1	,, 2·1	,,

The proteins of the yolk are vitellin and livetin, of which the former is a true phosphoprotein and the latter a pseudoglobulin.

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[1] There are apparently four different proteins in egg-white—ovalbumin, conalbumin, ovomucin, and ovomucoid. The ovalbumin makes up the greater part of the white. Ovomucin and ovomucoid are glycoproteins, and are only present in small amounts. See EICHHOLZ. (1898), *Journ. Physiol.*, **23**, 163; Farmers' Bull., No. 128, U.S. Dept. of Agriculture.

[2] See p. 160.

[3] For further analyses, which, however, do not differ essentially from the above, see LEBBIN. (1901), *Therap. Monatshefte*, **15**, 552; PLIMMER. (1921), *loc. cit.*; NEEDHAM. 1931; McCANCE and WIDDOWSON (1940) give rather lower figures.

[4] Compiled from figures given by NEEDHAM. (1931), *Chemical Embryology*, **1**, 283–4.

Vitellin contains some 1·3 per cent. of phosphorus and has relatively high proportions of the important amino-acids, cystine, tryptophane and tyrosine, a fact of some importance in embryonic—and other—nutrition. Livetin contains but little phosphorus. The proportions of vitellin to livetin are about 3·6 to 1.

The " fat " in the table is really " ethereal extract " and consists of true fats plus lipines. The fats are, of course, compounds of fatty acid and glycerine, and the fatty acids of egg fat are palmitic, stearic, oleic and possibly linoleic—the oleic and the other two being in the proportion of 2 : 1 : 1. The lipines are mainly represented by lecithin, but there are other members of the group present such as kephalin and sphingomyelin. These substances are of interest in nutrition because they too contain phosphoric acid, and can be used as a source of phosphorus for the bones of the developing chick. The relation of true fats to the remainder of the fat-like materials is about 2·5 to 1.

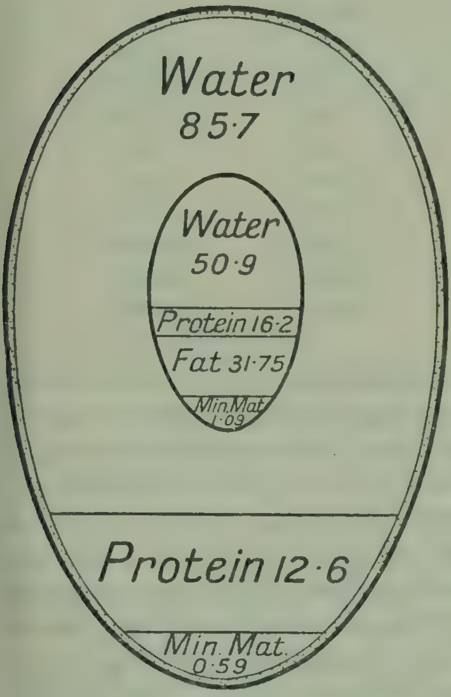
Water
85·7
Water
50·9
Protein 16·2
Fat 31·75
Min. Mat.
1·09
Protein 12·6
Min. Mat.
0·59

Fig. 17.—Percentage Composition of the White and Yolk of an Egg.

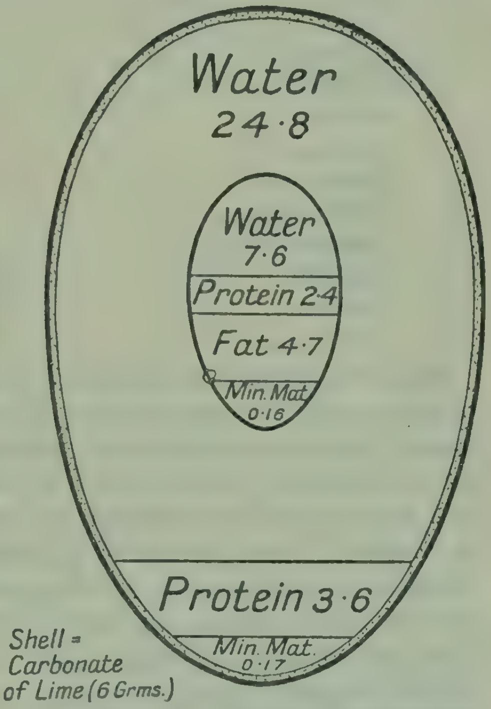
Water
24·8
Water
7·6
Protein 2·4
Fat 4·7
Min. Mat.
0·16
Protein 3·6
Min. Mat.
0·17
Shell = Carbonate of Lime (6 Grms.)

Fig. 18.—Actual Composition of an Average Egg weighing 50 grammes.

As much as 200 mgm. of cholesterol, mainly as free cholesterol, are to be found in each egg-yolk, which probably acts as a carrier of vitamin D.

All these unusual substances were for a long time believed to be in chemical combination with the protein, but more recently the general opinion is that the combination is only physical.

As regards the inorganic constituents, potassium, calcium and iron,[1] in addition to the phosphorus, are found in considerable amounts in the yolk. According to McCance and Widdowson 100 grammes of white and yolk have the following amounts in milligrammes of the "mineral elements."

	White.	Yolk.
Calcium	5·2	131·5
Chlorine	170·0	142·0
Copper	0·03	0·02
Iron	0·1	6·13
Magnesium	10·7	14·9
Phosphorus	33·0	495·0
Potassium	148·0	123·0
Sodium	192·0	50·0
Sulphur	183·0	165·0

We have, then, in the yolk of egg a remarkable food, for it contains a protein with a large amount of phosphorus and of high biological value, highly emulsified fats, which owing to their emulsification are very digestible, lecithin and its allies, also highly phosphorized, and very notable proportions of calcium and iron. The phosphorus is needed by the young chick partly to form bones and partly to form nucleoprotein, the calcium and the phosphorus are essential for bone formation, the iron [2] for the hæmoglobin of the blood. The fats contain vitamin A (88 I.U. per gramme yolk) and the sterols vitamin D (up to 5 I.U. per gramme yolk). Vitamins B_1 (1 I.U. per gramme) and riboflavine (0·5 to 0·6 milligramme per 100 gramme) are also present in the egg-yolk.

Consequently the great richness of the yolk in all (or most) of the materials needed by the young growing animal makes it a peculiarly valuable food for infants, especially those who are suffering from rickets.

Eggs contain almost no free purine or purine-yielding substance, and may therefore form part of the purine-free diet which is sometimes recommended in gout.

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[1] Socin. (1891), *Zeit. f. Physiolog. Chem.*, 15, 93.

[2] The iron is present not, as formerly supposed, in organic combination, but as an inorganic compound. R. Hill. (1930), *Proc. Roy. Soc.*, 107, 205. Thompsett. (1934), *Biochem. Journ.*, 28, 1536.

The ***composition of the whole egg*** may be summed up as follows:[1]

Shell	11·2 per cent.
Water	65·5 ,,
Nitrogenous matter	13·1 ,,
Fatty matters	9·3 ,,
Mineral elements	0·9 ,,

There is no difference in composition between eggs with dark shells and eggs with white shells, and no justification for the popular belief that the former are "richer" than the latter.[2]

The composition of the ***edible part*** (white and yolk together) may be ***compared with*** that of ***meat*** thus:[3]

	Egg.	Moderately Lean Meat.
Water	73·7	73·0
Protein	14·8	21·0
Fat	10·5	5·5
Mineral elements	1·0	1·0
Caloric value	158·0	137·0

It is seen at a glance that eggs contain almost the same total of nutritive matter as meat, but are relatively richer in fat and poorer in protein.

Eggs are thus admirably adapted chemically to supplement a food rich in carbohydrate, moderately rich in protein, but poor in fat. Such a food is found in rice and many cereals, and the addition of eggs to these in the form of puddings makes a complete food.

Composition of other Eggs. The composition of a goose's or duck's egg is very similar to that of the hen, but, of course, they are larger. An average duck's egg weighs about 2½ oz., a goose's egg from 5½ to 6½ oz.

Eggs when ***kept*** gradually lose water by evaporation and become lighter. A fresh egg should sink at once in a 10 per cent. salt solution (about 2 oz. to a pint), but the longer it has been kept,

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[1] Atwater. *Composition of American Food Materials.* Bull. No. 28, U.S. Dept. of Agriculture (revised edition). The percentage of shell is somewhat lower than that given on p. 359. McCance and Shipp (*loc. cit.*) found that the whole egg (excluding shell) contained 12·6 per cent. protein and 7·9 per cent. fat.

[2] See C. F. Langworthy. (1901), *Eggs and their Uses as Food,* U.S. Dept. of Agriculture. Farmers' Bull., No. 128.

[3] Atwater. *op. cit.* (average of sixty analyses).

THE COMPOSITION OF EGGS[1]

	Refuse. Per Cent.	Water. Per Cent.	Protein. Per Cent.	Fat. Per Cent.	Mineral Elements Per Cent.
Duck:					
Whole egg, as purchased	13·7	60·8	12·1	12·5	0·8
Whole egg, edible portion	—	70·5	13·3	14·5	1·0
White	—	87·0	11·1	0·03	0·8
Yolk	—	45·8	16·8	36·2	1·2
Guinea fowl:					
Whole egg, as purchased	16·9	60·5	11·9	9·9	0·8
Whole egg, edible portion	—	72·8	13·5	12·0	0·9
White	—	86·6	11·6	0·03	0·8
Yolk	—	49·7	16·7	31·8	1·2
Hen:					
Whole egg, as purchased	11·2	65·5	11·9	9·3	0·9
Whole egg, edible portion	—	73·7	13·4	10·5	1·0
White	—	86·2	12·3	0·2	0·6
Yolk	—	49·5	15·7	33·3	1·1
Plover:					
Whole egg, as purchased	9·6	67·3	9·7	10·6	0·9
Whole egg, edible portion	—	74·4	10·7	11·7	1·0
Turkey:					
Whole egg, as purchased	13·8	63·5	12·2	9·7	0·8
Whole egg, edible portion	—	73·7	13·4	11·2	0·9
White	—	86·7	11·5	0·03	0·8
Yolk	—	48·3	17·4	32·9	1·2

the nearer the surface it will float. There is no reason to suppose that preserved eggs are in any way less nutritious than fresh.

When an egg becomes ***rotten,*** alkaline sulphides are produced, apparently from the white, and these give to a rotten egg its very disagreeable smell. If an egg is boiled for a long time the same effect is produced in a minor degree, and it is well known that an egg so treated is apt to have a slight odour.[2]

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[1] U.S. Dept. of Agriculture, Farmers' Bull., No. 234. Other analyses quoted by NEEDHAM. (1931), *Chemical Embryology,* **1**, 240–1, are substantially the same.

[2] The green colour of the surface of the yolk of a hard-boiled egg is due to the sulphide set free from the white combining with the iron of the yolk. This may be prevented by boiling the egg no more than enough to set it and then rapidly cooling it in cold water. TINKLER and SOAR. (1920), *Biochem. Journ.*, **14**, 114.

The digestibility of eggs in the stomach depends largely upon the form in which they are taken. Some experiments made on a healthy man throw light on this subject.[1] Two eggs were given, cooked in different ways, and portions of the stomach contents were withdrawn at intervals, the time being noted at which any portion of egg ceased to be recovered. The results were as follows :

2 eggs lightly boiled have left the stomach in . . .	1¾	hours
,, raw have left the stomach in	2¼	,,
,, poached + 5 grammes of butter have left the stomach in	2½	,,
,, hard boiled have left the stomach in . . .	3	,,
,, as an omelette have left the stomach in . . .	3	,,

The figures speak for themselves. Eggs cooked in almost any way are digestible. Raw eggs, despite their reputation, may prove to be indigestible. Investigations in Mendel's laboratory suggest that they are by no means as useful in nutrition as lightly boiled eggs. Their avidin renders the biotin of the diet unavailable.

The difference in digestibility between hard- and soft-boiled eggs depends to some extent, also, on the degree to which the former are subdivided. If finely chopped up, they could probably be disposed of as easily as the soft-boiled eggs.[2]

As would be expected, raw yolk remains considerably longer in the stomach than raw white. It is noteworthy that all egg dishes call forth a much smaller secretion of hydrochloric acid than meat and fish.[2]

It must also be pointed out that ***idiosyncrasy*** plays a large part in the digestion of eggs. Some persons are unable to swallow even a small particle of egg without becoming violently ill, the symptoms ranging from slight urticaria to vomiting, syncope, and coma.

The ***absorption*** of eggs in the intestine seems to be very complete. It has been found that even when 21 hard-boiled eggs are taken daily they are absorbed as completely as meat, only 5 per cent. of the dried substance being lost.[3]

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[1] PENZOLDT. (1893), *Deut. Arch. f. Klin. Med.*, **51**, 535. See also HAWK, REHFUSS *et alii.* (1919), *Amer. Journ. Physiol.*, **49**, 254.

[2] HAWK and REHFUSS, (1926) found that hard-boiled egg remains in the stomach only ten minutes longer than soft-boiled. *Amer. Journ. Med. Sci.*, **171**, 359.

[3] RUBNER. (1879), *Zeit. f. Biologie.*, **15**, 115. For an account of later experiments, which, however, yielded results almost identical with Rubner's, see Farmers' Bull. No. 128, 17, U.S. Dept. of Agriculture; and AUFRECHT and SIMON. (1908), *Deut. Med. Woch.*, **34**, 2309.

Eggs, therefore, leave a very small residue in the intestine. This, coupled with the fact that they contain so much calcium, may perhaps explain their constipating effect on some persons.

Nutritive Value of Eggs. Chemical considerations have shown us that the nutritive value of eggs is due almost entirely to protein and fat. One egg contains enough of these to yield 70 to 90 Calories. Half a tumblerful of good milk or 1½ oz. of fat meat would yield about as much.

Roughly speaking, 15 to 20 eggs may be taken as the nutritive equivalent of 2 lb. of medium fat meat.

Their low carbohydrate content prevents eggs from being in any sense a complete food, and it would take 12–15 of them a day to supply even the amount of nitrogen required by a healthy man. They cannot be regarded as a *cheap* source of protein, though the convenient form in which their nutritive constituents are presented, and the readiness with which they lend themselves to the art of the cook, must always render them a most useful form of food. In addition to these considerations, the peculiar chemical composition of the yolk causes that part of the egg to be a valuable source of calcium, iron, and phosphorus, as well as vitamins A, B_1, riboflavine, and D, of which advantage may well be taken in the dietetic treatment of disease, more especially in early life. They lack vitamin C.

Duck Eggs. A word of warning is necessary about duck eggs. As long ago as 1926 the Ministry of Health drew attention to the possibility that undercooked duck eggs could cause gastro-enteritis. The ducks often are carriers of *bact. aetrycke*, pass them on to the eggs and, if the latter are imperfectly cooked, spread " food poisoning." Hens and turkeys suffer from microbes of the salmonella type, but so far these birds' eggs have not been incriminated as a source of food poisoning. German law compels duck eggs to be indelibly stamped as such, and advise that they should be boiled for eight minutes.[1]

Dried Eggs. The war of 1939–45 introduced us to a new product—spray-dried eggs. In the first World War, Cook's Farm Eggs gained some prominence and continued to be manufactured during the uneasy peace. Their composition was :

Protein	43·19	per cent.
Fat	41·92	,,
Non-nitrogenous matter . .	1·50	,,
Ash	3·15	,,
Moisture	10·24	,,

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[1] *Lancet,* (1945), **1**, 314.

The spray process of drying milk was applied to whole eggs and a very valuable commodity resulted. In fact it "saved the situation" for the cook during the war years. The spraying results in a very fine powder which easily "reconstitutes" with water. Some change in the physical nature of the proteins results, for dried eggs are not so useful as shell eggs in cake making. More baking powder seems to be necessary. It is claimed, however, that reconstituted dried eggs beaten at a temperature of 100° F. to 125° F. can be used as a basis for sponge cakes, and are as useful for that purpose as shell eggs. Cane sugar added to the egg before drying prevents the denaturation of the proteins and gives a better beat. Other sugars have an opposite effect.[1] There can be little doubt of their nutritive value. The analysis given by the Medical Research Council is:

Protein, 45·8 g.; Fat, 42·0 g.; Carbohydrate, 3·2 g.; Calcium, 219 mg.; Iron, 11 mg.; Vitamin A, 3000 I.U.; B_1, 1400 I.U.; C, 0; D, 240 I.U. per 100 grammes. Caloric value, 591 (163 per. oz.).

It is unfortunate that there are many so-called "substitutes" for eggs on the markets. Biologically and dietetically, there can be no substitute for the egg. Among these substitutes are sold the ***custard-powders.***

COMPOSITION OF CUSTARD-POWDERS

	Bird's[2] Custard-powder.	Goodall's Custard-powder.	Goodall's Egg-powder.	Borwick's Egg-powder.	Yeatman's Egg-powder.
Starch	86·25	84·45	51·03	26·38	52·32
Protein	0·59	0·58	6·01	2·96	6·00
Soluble colouring matter	0·88	0·90	—	—	—
Baking soda	—	—	15·33	50·70	22·11
Tartaric acid	—	—	13·69	10·33	11·37
Phosphates	—	—	0·24	—	—
Carbonates of calcium and magnesium	—	—	2·70	—	—
Chlorides and sulphates	—	—	—	—	—
Water	11·83	13·69	11·0	9·63	8·20
Mineral elements	0·45	0·38	—	—	—
	100·00	100·00	100·00	100·00	100·00

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[1] HAWTHORNE and GROVER. (1944), *Chem. and Ind.*, 422.

[2] Bird's custard powder has added vitamins A and D.

The majority of them consist chiefly of starch, to which a yellow colour is imparted by mixture with some vegetable dye—e.g. turmeric.

It is obvious that they have nothing in common with eggs except a yellow colour, and that their nutritive value can be in no way equal to that of a genuine custard. They are extremely popular in all parts of the country served with stewed fruits, with fruit pies and with suet puddings, but are useful in dietetics only as a vehicle for milk.

CHAPTER XIV

FOODS TAKEN CHIEFLY FOR PROTEIN (*cont.*)

MILK

There is probably only one subject upon which all dietitians agree, viz. the value of milk—generally speaking, cow's milk—in human nutrition. Milk is a food developed in nature for the feeding of the immature mammal. The only doubts which can arise about its use by man are, (i) is it wise to divert the food intended for the young of other mammals to man, and (ii) should adults take a food intended for the immature ? The answer to these two questions, from the dawn of history to the modern experimental era is undoubtedly " yes."

In the present chapter cow's milk alone will be dealt with. We shall reserve till later the study of human milk and the milk of some other animals.

Chemical Composition. As regards its chemical composition, milk occupies an almost unique position among animal foods, for it contains in itself representatives of all three nutritive constituents, proteins, carbohydrates, and fat. The avocado pear, nuts and the soya bean are practically the only other foods which have significant amounts of all three nutrients, to judge from McCance and Widdowson's analyses. The Medical Research Council includes the shell fish.

The ***proteins of milk*** constitute about 3 to 3½ per cent. of its total weight.[1] The principal protein is the substance called *caseinogen*,[2] which is not very soluble in pure water but is kept in solution in milk by the various inorganic salts present. The solution is not clear, but opalescent. It is least soluble at a p_H 4·6.

The other main protein of milk is an albumin (*lactalbumin*), which is present in very much smaller quantity than caseinogen, making up only about one-fifth of the total protein of cow's milk. In human milk it is *relatively* much more abundant. The biological value of the mixed proteins is the highest known and because of their large content of methionine are particularly useful for tissue building and regeneration.[1]

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[1] Average of all data in DAVIES' (1939) *The Chemistry of Milk*, Chapman & Hall, are protein 3·42, fat 3·67, lactose 4·78, mineral elements 0·73.

[2] " Casein " in American and Continental terminology.

The ***carbohydrate*** constituent of milk is *milk-sugar*, or *lactose*, which is present to the extent of from 4 to 5 per cent. It differs very much from cane-sugar, and in nothing more than in its comparative freedom from sweetness. In a substance, which serves as a food rather than as a condiment, this property is a valuable one. Were it not so, milk would pall upon the taste much more readily than it does. Another peculiarity of lactose is that it is hardly capable of being fermented by yeasts. As a consequence, it is better borne than other kinds of sugar in cases of advanced dilatation of the stomach accompanied by fermentation. On the other hand, it is readily converted into lactic acid by the lactic acid bacteria, a process which occurs in the souring of milk, and sometimes also in the intestine.

The ***fat of milk*** stands intermediate in amount between the protein and sugar in cow's milk, constituting about 3½ to 4 per cent. of the total weight. In the milk of other mammals the relative proportions vary remarkably, so that generalizations are impossible as the following table will show.[2]

Composition of the Milks of Various Mammals[3]

	Protein				
	Caseinogen.	Lactalbumin.	Fat.	Lactose.	"Mineral elements."
Ass	0·7	1·6	1·6	6·0	0·5
Buffalo	5·8	0·3	7·5	4·1	0·9
Cat	3·1	6·0	3·3	4·9	0·6
Cow	3·0	0·5	3·7	4·9	0·7
Dog	6·1	5·1	9·6	3·1	0·7
Echnidna aculeata	8·4	2·9	19·6	2·8	—
Elephant	3·1		19·6	8·8	0·6
Ewe	5·0	1·5	6·9	4·9	0·9
Goat	3·2	1·1	4·8	4·4	0·8
Human	1·0	1·3	3·8	6·2	0·3
Llama	3·0	0·9	3·2	5·6	0·8
Mare	1·2	0·1	1·2	5·7	0·3
Porpoise	11·2		48·5	1·3	0·6
Reindeer	8·38	1·51	17·09	2·82	—
Sheep	5·23	1·45	8·63	4·28	0·97
Sow	3·3	1·5	7·0	3·1	1·1
Whale	—	—	43·7	—	—

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[1] Himsworth and Glynn. (1945), *Proc. Roy. Soc. Med.*, **38**, 101; Croft and Peters. (1945), *Lancet*, **1**, 266.

[2] See also Davies. (1939), *op. cit.*, 7.

[3] Figures mainly from Davies. (1939), *op. cit.*

Fat exists in milk in the form of an emulsion of extraordinary perfection. The average diameter of a globule of milk fat is about 2·3 to 4·0μ, though there may be some with a diameter greater than 12. It will be evident that fat so finely divided as this must be particularly easy of digestion.

When milk is allowed to stand, the fat globules run together, and float to the surface as cream. If this is removed, ***skim milk*** is left; but when so prepared it still contains some 0·5 per cent. of fat, perhaps as much as 1 per cent. If the cream is removed by means of a centrifugal separator, its abstraction is much more complete; for separated milk usually contains less than $\frac{1}{3}$ per cent. of fat. Milk so prepared should be described as ***separated milk.***

Some fuller chemical details about milk fat have already been given under butter (p. 285).

"***Mineral Elements***" are fairly abundant in milk, forming about 0·7 per cent. Seeing that milk is the sole food of young animals, one is not surprised to learn that its different mineral ingredients are present in the same proportions as in the body of the particular animal which the milk is designed to feed.[1] Now, the chief tissues which a young animal has to build up are muscle and bone. For the former potassium phosphate, and for the latter calcium phosphate are required, and milk contains an abundance of both of these substances. To the rule that the mineral ingredients of milk correspond proportionately to those in the body of a young animal there is one apparent exception. Iron is an essential element in the body and especially in the blood; but iron is very scantily represented in milk.[2] Five pints of milk would be required to supply the amount of iron necessary for a full-grown man every day. To the young animal this scarcity of iron in milk is a matter of little moment. It enters the world with a full supply of iron already stored in its body, which it has obtained from the blood of its mother. Artificially fed babies require extra iron, for cow's milk has less iron than human milk.[3] In the adult, on the other hand, the lack of iron entails a deficiency in the supply required to keep the blood in proper condition, and for this reason persons who are kept for a long time on a purely milk diet may become anæmic.

There remains one other substance which, for the sake of convenience, may be considered under the mineral ingredients of milk: ***citric acid.*** It is rather astonishing to find this substance in milk at all, and yet about 13–0·23 per cent. is present, and it has been calculated that a good cow yields as much citric acid in the day as would be contained in two or three lemons.[1]

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[1] Man is an exception.

[2] Reis and Chakmakjian. (1932), *Journ. Biol. Chem.*, 98, 237, give the percentage of iron in cow's milk when milked into glass containers as 0·00014–0·00018, and when into normal containers as 0·00028.

[3] Mackay, H. *Med. Res. Council Spec. Rep.* No. 157.

As found in milk, citric acid is chiefly combined with calcium and magnesium. The solid particles sometimes met with in autoclaved milk consist chiefly of it.

In addition, milk is a good source of vitamin A and riboflavine. One pint of milk may yield from 776 to 1520 I.U. of vitamin A.[2] Vitamin B_1 is present to about 23 I.U. per 100 c.c., though American figures are lower; riboflavine to 0·2 milligrammes and nicotinic acid to 0·057 milligrammes.[3] The other members of the B complex are present. Vitamin C is at about the low level of 2 milligrammes per 100 c.c. Figures for vitamin D are 7 to 10 I.U. for English milk between November and March, rising to 55 I.U. in July and possibly higher in August.[4]

Last, but not least, amongst the constituents of milk is ***water.*** It forms by far the largest proportion of the milk (87 to 88 per cent.), and holds the other ingredients in suspension or solution. The hydrogen ion concentration of fresh cow's milk is P_{H} 6·5.

One may now sum up what has been stated about the chemical composition of milk in the following table:

COMPOSITION OF COW'S MILK

Water . .	87 to 88 per cent.	Fat . . .	3½ to 4½ per cent.
Protein . .	3 „ 3½ „	Mineral elements[5]	0·7 „
Sugar . .	4 „ 5 „		

The average figures of thousands of analyses are: Water 87·1, total solids 12·69, caseinogen 2·86, albumin plus globulin (coagulable proteins) 0·56, fat 3·67, lactose 4·78, mineral elements 0·73 per cent.

These figures merely represent the average composition of a sample of good milk. They are not to be understood to apply to every specimen of milk encountered, for milk varies greatly in composition.

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[1] HENKEL. (1888), *Münch. Med. Woch.*, **35**, 328.

[2] The MEDICAL RESEARCH COUNCIL figures are about half these, and figures from a private communication by COWARD and BRUCE, nearly double.

[3] Much higher figures are quoted as the result of biological assays. It must not be forgotten that milk may promote the growth of nicotinic-acid-producing microbes in the large intestine.

[4] KON. (1943), *J. Dairy Res.*, **13**, 216.

[5] Calcium forms 0·120 per cent., potassium 0·160 per cent. (an unexpectedly high figure) and phosphorus 0·095 per cent.

To some extent these variations in composition are unavoidable, depending as they do on the breed and age of cow from which the milk is obtained, on the way in which the cows are fed, and on the period which has elapsed since calving.

In the mixed milk obtained from a large number of cows these variations must to a considerable extent neutralize one another. Hence it is that the total milk from one dairy varies less in composition than that from any one cow in it, and the popular prejudice in favour of feeding an infant on milk " from one cow " thus rests on a false basis. The " solids not fat " are closely grouped round an average of 8·74, but even so they may vary from 6·24 to 10·24 per cent. The fat of the milk of a Friesian herd may be 3·55 per cent. and from a Guernsey, 5·19 per cent.

What composition should be expected ? On this point, unfortunately, some difference of opinion exists. Analysis has clearly shown that an average sample of good milk contains about 3·8 per cent. of fat. There is no legal definition of milk, but it is assumed, in this country, that if milk has less than 3 per cent. fat, and 8·5 per cent. " total solids not fat," it is adulterated. A quality standard based on total solids and on the number of microbes per millilitre is advocated by Davis [1] of the National Institute for Research in Dairying, which certainly would be better than the present haphazard scheme.

From what has been said of the chemical composition of milk, it might naturally be regarded as a fluid form of food, and indeed it is often one of the chief elements in a so-called " fluid " diet. Strictly speaking, however, milk is not a fluid food. It is only a fluid outside the body. So soon as milk enters the stomach it undergoes a change by which it very quickly becomes solid. It is then said to be coagulated or clotted. This ***coagulation*** is due to a change brought about in the caseinogen by the ferment called " rennin." The exact nature of the change which the caseinogen undergoes is still obscure, but it seems to be split up by the rennin into two proteins, casein and whey albumose. The union of casein and calcium produces the clot.[2]

The coagulation of milk is what occurs in the making of ***junket.***

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[1] DAVIS. (1944), *Food Manufacture,* **19**, 423.

[2] English physiologists, as stated above, apply the name " caseinogen " to the chief protein of milk, and restrict the term " casein " to caseinogen which has been altered by coagulation. This nomenclature has the advantage of emphasizing the difference between the products of curdling and clotting above described. Adopting it, one would say that when milk is curdled caseinogen is thrown down in a flocculent form ; when milk clots, the caseinogen is converted

In that process, rennet (an extract of the lining of the fourth or true stomach of the calf or lamb) is added to the milk raised to body temperature, which is then set aside in a warm place until it is solid. At first the milk forms a jelly, but by and by the curd shrinks and a yellowish fluid is squeezed out of it, which is the "whey." The rennet which is used in this operation is derived from the lining membrane of the stomach of the calf, but exactly the same ferment is present in the human stomach, and it is important to remember that all raw milk is converted in the stomach into junket very shortly after it has been swallowed. We shall return in greater detail to this subject when we come to the digestion of milk.

At present it may be pointed out that the curd of milk consists primarily of the calcium caseinate. In process of setting, however, the casein entangles the fat of the milk in its meshes, so that curd consists of the casein along with the fat.

It usually also contains some of the sugar of the milk, for the whey is never entirely squeezed out.

The ***"curdling" of milk*** must be distinguished clearly from the process of "clotting" just described. When milk "curdles," its caseinogen is simply thrown down in the form of a precipitate without undergoing further change. When milk "clots," the caseinogen undergoes partial digestion and one of the digestion products unites with calcium to form a clot.

Curdling is due to the production of lactic acid in the milk, which turns the caseinogen out of its partnership with calcium salts, and the caseinogen, being in itself not soluble, falls down as a flocculent precipitate when the P_H of the fluid reaches the isoelectric point.

The production of the lactic acid is due to a splitting up of milk-sugar by the agency of the lactic acid bacteria. The true lactic acid bacteria change 90–98 per cent. of the milk's lactose to lactic acid, and there is also a production of succinic, acetic, and propionic acids and of carbon dioxide. Coliform organisms also manufacture lactic acid among a wider range of products.

Effects of Heating upon the Composition of Milk. When milk is warmed in an open pan a tough "skin" forms on the top. This skin is due to a Ramsden phenomenon. The caseinogen and lactalbumin are concentrated at the air-liquid interface and

into casein. Americans and others call the chief protein of milk "casein" and the solid result of rennin action "paracasein."

Investigation suggests that the calcium is in close relation with the caseinogen in milk forming calcium caseinogenate. Curdling with acid removes the calcium and forms acid caseinogen. The clot of milk is calcium caseinate.

irreversibly precipitated. Fat and deposits of tricalcium phosphate are also entangled in the skin.

If the skin is removed, another straightway appears, and by continuing the process the milk undoubtedly loses some of its nutritive value. The loss is never great, however, for 100 c.c. of milk, if boiled for a quarter of an hour, lose at most only 0·273 gramme of protein. After prolonged boiling, and to a less degree after pasteurization, the soluble calcium of the milk is somewhat diminished and to this extent the nutritive value of the milk may be slightly impaired.[1]

Other changes observed in milk heated for a long time are that it becomes of a somewhat brownish colour, and altered taste. The change in colour seems to be due in part to a caramelization of the sugar in the milk, but in part also to more obscure alterations.[2] The change in taste sets in quite suddenly when a temperature of 70° C. is reached. It can be obviated to a large extent by allowing the milk to stand for some time, after being boiled, and then straining it.

The caseinogen also seems to undergo some alteration on boiling, for boiled milk coagulates more slowly than raw milk. To this point we shall return later.

That milk is a valuable food, if not *the* most valuable food, is agreed by all dietitians, and national governments have accepted the verdicts of scientists. Colossal efforts have been made by them to increase the production and consumption of milk. By subsidizing milk, by decreasing its price to pregnant and nursing mothers, to infants under five and to school-children, the consumption of liquid milk in this country has been increased during the years of the second World War by 25 per cent,[3] i.e. from 767 million gallons per year to 1048 million gallons. Much of this has been, however, diverted from manufacture, so that the total increased production is much less spectacular. The increased consumption must be continued and further developed if Great Britain is to reach the aim of dietitians, viz. 1 pint per head per day, or 2,054 million gallons per year.

That milk arrives in the towns of this country in a satisfactory state can hardly be claimed by even the most fanatical upholder of the consumption of raw milk. Milk as drawn from a healthy and perfectly clean cow is a practically sterile fluid. Such ideal conditions, however, are difficult, and almost impossible to attain at present and the production and consumption of milk presents us with a dilemma: either we must insist that all milk sold should be absolutely clean milk or it must be treated before consumption to make it safe.

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[1] H. E. Magee and Douglas Harvey. "Studies of the Effect of Heat on Milk." (1926), *Biochem. Journ.*, **20**, 873.

[2] Wright. (1924), *Biochem. Journ.*, **18**, 245.

[3] *Food Manufacture.* (1945), **20**, 78.

The sources of danger are (i) disease in the cow, and (ii) contamination with pathogenic microbes in the course of production, transit to the central depots and delivery to the customer. The cow may be suffering from tuberculosis or from undulant fever [1] and pass the microbes causing these diseases into the milk secreted. The milker may be a carrier of diptheria, dysentery, paratyphoid, scarlet fever or typhoid germs and so infect the milk. The containers—buckets, churns, etc., may be washed with water infected by pathogenic germs, or such germs may be transmitted by flies. Then there is the danger of contamination by dust. The germs of undulant fever may live for many months in dung and it is unfortunately the fact that much of our milk is contaminated with dung. The bulking of milk at distributing centres, or earlier, hands on the milk infection of one farm to the whole of the milk bulked, e.g. in Bournemouth in 1936, a turnover of 1600 gallons of milk per day, collected from 37 suppliers, was contaminated by one supply of 15–20 gallons per day infected at the farm. There were 718 cases of typhoid with 51 deaths.[2] Unfortunately there is evidence of transmission of the diseases mentioned in plenty. Transmission of diptheria by the wife of a farmer when straining the milk was demonstrated in 1943.[3] Even milk from tuberculin-tested herds is at times contaminated with bovine tuberculosis.[4] "Press-in" discs for closing the mouths of milk bottles have been held responsible for paratyphoid and typhoid in America.[5] An outbreak of typhoid in Melbourne was traced to the milk of one farm, where there was a typhoid carrier and with the removal of that carrier the outbreak died out.[6] Five per cent. of all milk samples, in this country bacteriologically tested, contain tubercle bacilli.[7] The deaths from bovine tuberculosis, almost certainly transmitted by milk, are estimated at 2000 per year in this country.[8] Such a death-rate indicates great suffering in intestines, joints and glands among children who survive. These are but a small sample culled mainly from one medical journal

[1] WILSON. (1944), *Proc. Nut. Soc.*, **2**, 158.

[2] ENOCK. (1943), *This Milk Business*, 75–7.

[3] GOLDIE and MADDOCK. (1943), *Lancet*, **1**, 285.

[4] SUTHERLAND. (1943), *Lancet*, **1**, 316. [5] *Lancet*, (1943), **1**, 687.

[6] MERRILEES. (1943), *Lancet*, **1**, 803. [7] *Lancet*, (1945), **1**, 187.

[8] GARROD. (1943), *Lancet*, **1**, 276; WILSON. (1944), *Proc. Nut. Soc.*, **2**, 158.

during six months. It is no wonder that the many medical men look upon milk as a highly dangerous food.

There is a great distinction between safe milk—which we cannot afford to wait for—and clean milk, which we may hope to get in time.[1] The question is: how are we to make milk safe, until we can be sure of clean milk? The answer is emphatically *pasteurization.* This answer will be hotly contested, but frankly we cannot understand the case against it. Pasteurization consists in raising the temperature of the milk to a definite degree and maintaining it at that temperature till the pathogenic microbes are destroyed and then at once cooling it and delivering it into sterilized containers. The length of time the milk is exposed to the raised temperature depends on that temperature. At 145° F. the time is 30 minutes (the holder process), but at a higher temperature, the time necessary for the destruction of pathogenic microbes is much shorter. At 162° F. it may be as low as 15 to 16 seconds. (High temperature-short time process or the flash process.) Both methods are in use in this country and the United States. The holder process is being superseded by the flash process, which is now permissive in this country. Both methods need technical skill in the operator and this is particularly true of the flash process and, owing to shortage of skilled labour during the war of 1939–45, some milk has been imperfectly pasteurized.[2] It should not be impossible, however, to make the apparatus fool-proof.

The advantage of pasteurizing milk lies not only in the destruction of pathogenic microbes. The keeping quality is much enhanced. If ordinary milk is pasteurized in the laboratory by the holder process and held at 34° F. it will keep without significant change for one month.[3] It is safe to say that no milk could be used in our great cities without pasteurization, so that the position of affairs is this: a large majority of the nation would have to do without this admirable food if a ban were placed upon pasteurization.

There is no evidence that pasteurization appreciably alters the food value of milk. Laboratory experiments have shown that the only nutritive losses suffered by the known constituents of milk are a destruction of some 20 per cent. of vitamin C and of about 10 per cent. of vitamin B_1.[4] No one advocates milk as a source of these vitamins, for its contribution in a mixed diet under the best conditions is small. There is no loss of vitamin A, riboflavine or vitamin D. Experiments on calves by the Hannah Research

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[1] MONCRIEFF. (1943), *op. cit.*

[2] SUTHERLAND. (1943), *Lancet*, **1**, 316.

[3] MATTICK. (1944), *Proc. Nut. Soc.*, **2**, 141.

[4] KON. (1944), *Proc. Nut. Soc.*, **2**, 153.

Institute leave no doubt of its value as a food. The growth response of these calves was as great as—actually slightly greater than—the growth of the controls on the milk from the same source, but unpasteurized, and whereas none of those on pasteurized milk contracted tuberculosis, several of those on raw milk did. If no difference between the two milks as regards nutritive value can be shown on calves it is unlikely that there is any difference for human beings. For experiments on the value of pasteurized milk in the feeding of children, see p. 386.

For ordinary purposes there is little doubt that simply boiling the milk for a few minutes is the simplest and most satisfactory method of ridding the milk of pathogenic microbes. If carried out in a double saucepan, very little change in taste of the milk results, especially if it is rapidly cooled after removal from the fire and subsequently strained, as already described.

There is every reason to advocate the habitual application of one or other of these methods to milk before it is consumed as food; and one looks forward to the day when the drinking of raw milk will be considered as barbarous a custom as the eating of raw meat is at present.

Preservation of Milk. The commonest methods of preserving milk are by evaporation or desiccation.

Evaporated milk (usually spoken of in this country as unsweetened condensed milk) is made on a large scale in America. By evaporation *in vacuo* the water content of the milk is reduced by 60 to 65 per cent., the fat is homogenized to break up the globules and the product is finally sterilized. Such a milk is germ-free and the evaporation being conducted in the absence of oxygen there is no appreciable loss of vitamins A and D, but there is a loss of 50 per cent. of the vitamin B_1, 10 per cent. of riboflavine and 60 per cent. of vitamin C.[1]

By the method of ***desiccation,*** milk is passed in a thin layer between two heated rollers, or sprayed into a current of hot air, in such a way that most of the water is immediately evaporated, and a fine powder results, which contains all the original solids of the milk in a perfectly soluble form. There are now many brands of dried milk on the market, of which the table on the opposite page may be regarded as giving the approximate composition.

The nutritive value of dried milk is fully equal to that of ordinary milk and it may be regarded as practically sterile, and it is more digestible.

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[1] KON. (1944), *Proc. Nut. Soc.*, **2**, 149.

Composition of Dried Milk

	Whole.	Skimmed.
Moisture	4·0 per cent.	5·0 per cent.
Proteins	25·6 ,,	35·8 ,,
Fat	26·7 ,,	0·7 ,,
Milk sugar	35·6 ,,	47·9 ,,
Calcium	0·895 ,,	1·225 ,,
Iron	0·8	1·0 mg. per 100 gms.
Vitamin A	1070	30 I.U. ,, ,, ,,
Vitamin B_1	100	330 ,, ,, ,, ,,
Vitamin C	0	0 ,, ,, ,, ,,

Digestibility of Milk

It might be supposed that milk, being a fluid, would only remain a short time in the stomach, and rapidly pass on into the intestine. We have seen, however, that milk is only a fluid outside the body.

Clotting of Milk in the Stomach. When it enters the stomach it sets into a solid clot, owing to the action upon it of rennin. Now, the gastric juice is an acid fluid, and it is at first sight surprising that *curdling* does not take place rather than clotting. That this does not happen is no doubt to be attributed to the fact that the proteins of the milk unite with the acid first secreted by the stomach, and give the rennin time to act before the mixture has attained an acid reaction.

Whether this is the correct explanation or not, there can be no doubt of the fact that shortly after milk has been swallowed it is converted into a solid mass.

What the use of rennin is in the stomach is very difficult to see. Certainly clotting is not a necessary preliminary to the digestion of milk, for the latter process can be carried on artificially outside the body to its most advanced stages, with the milk remaining fluid all the time. There is also ample provision for the digestion of milk in the intestine, and if it is so prepared that clotting in the stomach cannot take place, its ultimate digestion is in no way interfered with, nor is it found that patients from whom the stomach has been entirely removed for disease have any difficulty in digesting milk. Rennin, in fact, would almost appear to be a superfluous ingredient in the gastric juice, and its presence there is rendered all the more inexplicable by the fact that it occurs also in such situations as the gizzards of fowls, where milk is never found at all.

After the clot of casein has formed in the stomach, it shrinks into a tough and leathery mass, which offers great resistance to the digestive efforts of the organ. Were the milk merely curdled, the case would be quite different; for the particles of precipitated caseinogen are dissolved with comparative ease. This is one of the reasons why butter-milk and koumiss are often found to be more "digestible" than ordinary milk.

The investigations of VAN SLYKE and HART have thrown a light on the digestion of casein. Calcium caseinate, which is the clot formed by rennin, forms a flocculent curd, which is not digested by pepsin unless acid is present, but passes almost straight into the intestine. This happens in young infants, whose stomachs secrete little or no hydrochloric acid. If acid is present, casein is set free, and forms a much denser clot, and is digested by pepsin. If hydrochloric acid is in excess, casein hydrochloride is formed, which sets into a still tougher curd, and takes still longer to digest.

If, then, we wish to lighten the labours of the stomach in the digestion of milk, we must endeavour so to arrange matters that the milk shall not form a tough and dense clot after it has been swallowed.

Now, the density of the clot which milk forms in the stomach depends, on the one hand, upon the amount of caseinogen and calcium salts which it contains, and on the other hand, upon the degree of acidity of the gastric juice. The richer in caseinogen and soluble salts of calcium the milk is, and the more acid the gastric juice, the tougher is the clot. On the other hand, by reducing the proportion of these different factors, the clotting of the milk can either be prevented altogether or made to take place in such a way that the clot is not of great toughness and density.

Obviously mere ***dilution of the milk with water*** lessens the proportion of lime salts and caseinogen, and will increase its digestibility. ***Dilution with lime-water*** is probably not more efficacious than dilution with ordinary water,[1] unless it be in virtue of its slight alkalinity. It has been found, however, that the addition of even large quantities of such an alkali as bicarbonate of soda to milk does not prevent clotting in the stomach.

Barley-water is sometimes recommended as a diluent instead of ordinary water. Whilst it has no greater power of preventing clotting than ordinary water, it seems to some extent, by its colloidal properties, to prevent the clot from shrinking into a tough mass. This is due to starch which it contains.

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[1] See F. W. WHITE. (1901), "Observations on Milk Coagulation and Digestion" (Abstract in *Boston Med. and Surg. Journ.*, **145**, 13).

Wright[1] showed that the coagulation of milk can be prevented by the addition of one-fiftieth of its volume of a 25-per-cent. solution of citrate of soda, which acts by converting some of the soluble lime salts into insoluble calcium citrate. Such ***citrated milk*** is employed with success in the feeding of infants. The presence of the citrate can hardly be detected by the palate, and milk contains such a large excess of calcium salts that the removal of part of them is no disadvantage.

Aeration of the milk (such as can be effected by the use of the "Sparklets" process) is another important means of combating density of clotting. Milk so prepared clots rapidly, but the clot is very friable. It is the combination of aeration and dilution that renders "milk-and-soda" so much more digestible than plain milk.

The presence of much acid, as has been mentioned, favours the retraction of the clot into a leathery form. Now, the degree of acidity of the gastric juice varies in different individuals within fairly wide limits, and that may explain why some people find milk so much more easy to digest than others. For this reason, too, milk may sometimes disagree in those cases of dyspepsia which are caused by over-acidity of the gastric juice.

Another method of preventing the formation of a dense clot is by mixing the milk with some substance which will get in between the particles of casein, as it were, and keep them apart, so that they do not run into a solid, tough mass, but form a more or less spongy clot. Mucilaginous fluids, such as barley-water, act, as we have seen, in this fashion. Thickening the milk with a little cornflour or gruel acts similarly, so does mixture with other foods. Milk is thus more easily digested if eaten along with some solid food—e.g. a biscuit—than when drunk straight off by itself.

Boiled milk is found to clot more slowly both *in vitro* and *in vivo*, and to give a less dense clot, than raw milk.[2]

The exact ***time that milk remains in the stomach*** under ordinary circumstances has been determined by causing a healthy man to drink a definite quantity of milk, and then washing out the stomach at short intervals or by taking advantage of people who can regurgitate at will.

In a series of experiments on the gastric response to foods, Rehfuss, Hawk, and their colleagues[3] made the following observations on such a man:

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[1] "On the Possible Advantages of Employing Decalcified Milk in the Feeding of Infants and Invalids." *Lancet*, (1893), **2**, 194; GONCE and TEMPLETON. (1930), *Amer. Journ. Dis. Child.*, **39**, 265.

[2] BRENNEMANN. (1913), *Journ. Amer. Med. Assoc.*, **1**, 575.

[3] *Amer. Journ. Physiol.* (1919), **48**, 411.

(1) Milk (500 c.c.) drunk rapidly, leaves the stomach rapidly and produces smaller curds than milk drunk slowly or sipped. Sipping produces large tough curds which remain a long time in the stomach.

(2) Raw milk produces rubber-like curd; milk, boiled 5 minutes, smaller and more digestible curds which leave the stomach earlier.

(3) Skimmed milk produces tough, hard curds; full milk softer curds and cream very soft curds. The last, however, leave the stomach but slowly.

(4) The addition of bicarbonate of soda produces smaller curds, not so small as those of boiled milk, which stayed longer in the stomach than those from untreated milk.

(5) Pasteurized milk is intermediate between raw and boiled milk.

(6) There is no observable difference between warm and cold milk as regards the size of curds formed and the rate of passage through the stomach.

One or two other points bearing on the digestibility of milk still remain to be mentioned. They specially affect its use in diseases of the stomach.

In the first place, it must be pointed out that, thanks to its protein, phosphates and citrates, milk can act as a powerful buffering agent.[1] In some diseases of the stomach, such as ulceration, in which it is desirable to buffer the acidity of the gastric juice, this property of milk makes it a valuable article of diet. It has also been pointed out by Pavlov that, in proportion to the amount of nitrogen it contains, milk requires for its digestion a weaker gastric juice than any other food. Hence, the secretory work required of the stomach for its digestion is small, and this is another point in its favour in many diseased conditions of the stomach. The fat which milk contains also exerts a restraining influence on the amount of gastric juice secreted. Lastly, milk, like soup, and a few other articles of diet, seems to produce a secretion of gastric juice independently of reflex nervous influences. It is therefore as sure to be digested if poured into the stomach through a tube as if it had been swallowed in the ordinary way. This is by no means true of most foods.

Absorption of Milk

Leaving the stomach, the milk reaches the intestine, where its digestion is completed by the pancreatic juice. This juice acts very powerfully on milk—more so than the gastric juice. By reason of this provision there is no need to fear that milk will escape digestion, even if it be so prepared that it does not remain in the stomach, but rapidly passes through into the intestine.

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[1] Ten c.c. of cow's milk can neutralize 4 c.c. of decinormal sulphuric acid.

The question next arises, Is the digested milk completely absorbed, or does it leave behind any considerable amount of waste residue? This question may be approached by investigating the degree to which the different constituents of milk are absorbed when isolated and given alone. Proceeding in this way, it has been found that the casein of milk is the best absorbed of proteins. It is absorbed as well as, or even rather better than, the protein of meat, whilst the fat of milk enters the blood quite as readily as the fat of beef. And one may note in passing the interesting fact that the fat of aerated milk is absorbed rather better than that of milk which has not been so treated. We are not aware of any experiments in which milk-sugar was given by itself, but it is usual to assume that it is completely absorbed.

Considering these facts, one would naturally expect to find that when milk was given as a whole it would be well absorbed. If the different components of it are so completely received into the blood, surely the whole of them given together will enter the blood with equal ease and completeness? But yet it is not so. Milk, *when given by itself as the exclusive diet of an adult*, is not very well absorbed—worse, indeed than any other animal food. Even under favourable conditions, only about 90 per cent. of the energy theoretically obtainable from milk is so obtained. The rest is lost as unabsorbed waste. Thus, if 2 litres of milk are taken daily, the loss of dry substance amounts to 5·7 to 7·8 per cent. On 3 litres the waste rises to 10·2 to 11·16 per cent. (Rubner). Prausnitz found a loss of 9 per cent. when 3 litres were consumed daily. One gramme of dried milk ought to yield 5·733 Calories. Owing to defective absorption, it only yields in the body 5·067 Calories. The loss affects the proteins and fat about equally, and, in a notable degree, the inorganic constituents and carbohydrates as well.

These results apply only to the case of adults, and when milk is the sole food. When the milk forms part of a mixed diet it is much better absorbed. Thus, in an average of ten experiments given by Wait, in which milk was the exclusive food, only 92·1 per cent. of the protein and 86·3 per cent. of the carbohydrate were digested; but in five experiments in which the diet consisted of bread and milk the proportion digested rose to 97·1 per cent. of the protein and 98·7 per cent. of the carbohydrates. The large amount of water which milk contains seems to interfere with absorption when it forms the sole diet.[1]

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[1] *Nutrition Investigations at the University of Tennessee.* U.S. Dept. of Agriculture. Bull. No. 53, p. 43.

It is an interesting and remarkable fact that milk is much better absorbed by young children than by grown-up persons.[1] Thus, even up to the age of 12 the loss of nitrogen, when milk is given alone, is only 4·4 per cent., as compared with more than 11 per cent. in the adult.[2] In the case of babies absorption is even more complete, the difference being to a large extent due to a more perfect absorption of the inorganic constituents, the reason for which is the greater demand for calcium salts in the infant. This reacts favourably on the absorption of the fat of the milk, for unabsorbed calcium salts are apt to form insoluble soaps with the fat, and so hinder its absorption.

The ***comparative absorption of boiled and unboiled milk*** has been the subject of a good deal of experimental investigation. Taking the whole of the evidence, the conclusion seems to be justified, that just as boiling does not appreciably diminish the digestibility of milk in the stomach, so it does not to any important extent interfere with its absorption in the intestine. One need have no fear, therefore, that the great advantages of boiling are purchased at the cost of any noteworthy diminution of digestibility or absorption.[3]

Two other points relating to the behaviour of milk in the intestine call for mention. The first is that milk seems to be absorbed with less expenditure of energy—that is to say, with less wear and tear upon the part of the intestine, than any other food (Pavlov). This no doubt explains in part the great value of milk diet in many intestinal diseases.

The other point is that milk seems to exercise a restraining influence upon putrefactive processes in the intestine. The explanation of this, whether it is to be attributed to the casein or to the influence of acids produced from the milk-sugar, is still disputed, but of the fact there appears to be no doubt.

NUTRITIVE VALUE OF MILK

It is frequently said that milk is a perfect food. Now, this is an exaggeration. There is no such thing, except theoretically, as a perfect food. But milk does come very high on the list of all sound foods. A perfect food must supply first-class protein, highly assimilable fats and carbohydrates, all the "mineral" elements in their right proportions, and all the vitamins. All this it should do at a moderate cost and in reasonable bulk.

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[1] See RUBNER and HEUBER. (1898), *Zeit. f. Biologie*, **36**, 1; UFFELMANN (quoted by Marcuse). (1896,) *Pflüger's Archiv.*, **64**, 223; CAMERER. (1880), *Zeit. f. Biologie*, **16**, 493.

[2] PRAUSNITZ. (1889), *Zeit. f. Biologie.*, **25**, 533.

[3] Experiments on young rats (*Journ. Hygiene*, 1909, **9**, 233) showed no diminution in the nutritive value of milk when boiled, or even when evaporated and dried.

Milk supplies first-class proteins and the minimal day's ration is found in 1 quart—not an unreasonable quantity and costing 9*d.* Even at this high price per quart milk compares very favourably with meat.

Its fats are highly assimilable and decrease the need for vitamin B_1. Its carbohydrate, while not very assimilable, is none the less very useful in metabolism.

Milk contains excellent supplies of calcium and phosphorus, but is deficient in iron. Of the vitamins it possesses A, riboflavine and vitamin K in considerable amount, it is not devoid of B_1, though its content of C and D are not worth considering.[1] No other food than eggs can be said to be so valuable as milk.

As sole food milk is too bulky, contains too little iron, and is not completely assimilable.

We conclude, then, that milk is not a perfect food, but it is admirably fitted to supplement the deficiencies of other articles of diet. It is one of the cheaper sources of animal protein. Ninepenny-worth of whole milk yields as much protein as tenpenny-worth of beef-steak. But milk has the advantage over beef of containing a considerable amount of carbohydrate in addition to its protein and fat, and a quart of good milk is equal in Calorie value to a pound of lean beef-steak. Skim milk is an even better source from which to supplement any lack of protein in the diet, for it supplies that constituent in a cheaper form than any other animal food except salt fish. Its

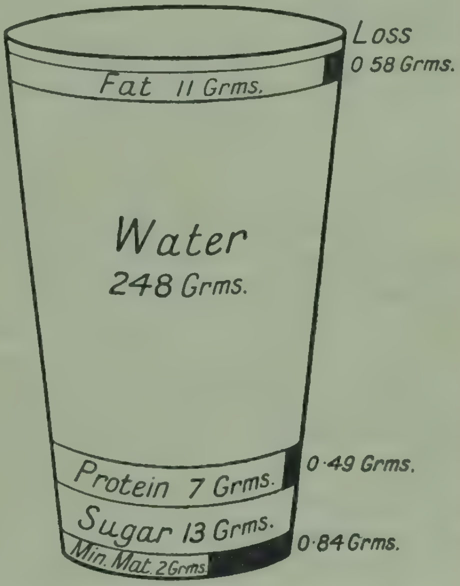

FIG. 19.—ACTUAL COMPOSITION OF A TUMBLERFUL OF ORDINARY MILK AND THE PERCENTAGE OF LOSS FROM NON-ABSORPTION.

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[1] The cholesterol content of cow's milk—10 to 17 milligrammes per 100 c.c.—gives it its antirachitic power on irradiation, which may be as much as 67 I.U. per pint. BICKNELL and PRESCOTT. (1942), *The Vitamins in Medicine*, 463.

great value in the dietary of persons to whom economy is of importance cannot be overestimated. It is in carbohydrate that milk is specially deficient. Hence it should be used chiefly in conjunction with other foods rich in that ingredient. Such a food is bread. Bread and milk sufficient to give 1000 Calories costs approximately one-eighth of what a lunch to supply the same would cost at a cheap restaurant.

The claims of skim milk to be regarded as a valuable source of food are fully justified, and should be carefully considered by all who are responsible for drawing up an ample and economical dietary for large numbers of persons—such, for example, as the inmates of public institutions. During the year 1943 the students of one of us (V. H. M.) discovered that rarely did the canteens and institutions they investigated make full use of the " household milk " which was available, or indeed of dried eggs, thus neglecting an admirable source of first-class protein and calcium.

Unfortunately, the prevailing tendency is to regard milk as a beverage rather than as a food. This is a great mistake, in proof of which we cannot do better than quote Dr. Corry Mann's classical work on " Diets for Boys during the School Age." [1] This was an experiment, lasting in all three years, on the influence on growth in height and weight of a carefully selected and scientifically controlled group of English boys, between the ages of 7 and 11 years, of the addition, each day to their diet, of one pint of pasteurized and homogenized milk. A group of 41 boys in the first 12 months gained an average of 6·98 lb. per boy, and grew an average of 2·63 in. in contrast with the control figures of 3·85 lb. and 1·84 in. respectively. This increased rate of growth was no " flash in the pan " but was maintained even into the third year of the experiment. No other food added in control experiments produced anything like so great an increase, though it may be noted that the addition of New Zealand butter was distinctly advantageous.

Apart from the marked gain in weight and height there was a general improvement in their physical condition—a loss of tendency to chilblains, to roughness of skin, and to lordosis. " After eighteen months," the report states, " a casual visitor entering the dining-hall, where the boys of nineteen houses sit at table, would never fail to recognize the table of that house which was alone receiving the extra ration of milk, the boys of that house being obviously more fit than those of any other house. In addition they became far more high spirited and irrepressible, being often in trouble on that account. . . .

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[1] CORRY MANN. (1926), *Med. Res. Council Report*, No. 105 ; CHANEY. (1923), *Amer. Journ. Dis. Child.*, **26**, 337 ; MORGAN, HATFIELD and TANNER. (1926), *ibid.*, **32**, 837 ; MCCOLLUM, ORIENT-KEILES and DAY. (1939), *The Newer Knowledge of Nutrition*. Fifth Edition.

"Furthermore, during the winter of 1923–4 there was complete absence of illness among the boys with the milk ration, although in other houses . . . the sickness rate had been somewhat higher than usual owing to naso-respiratory catarrh (influenza) and to a limited outbreak of measles and scarlatina."

Confirmatory observations made on groups of school-children in Scotland[1] showed that an addition of $\frac{3}{4}$ to 1 pint of milk to the daily diet caused a rate of growth and weight 20 per cent. higher than that of children who did not receive extra milk or who were given its Calorie equivalent in the form of biscuits. Separated milk (machine skimmed) was found to be quite as effective as whole milk, which confirms the high opinion of its value already expressed.

Milk as an article of diet in disease occupies a unique position. No single food, it may safely be said, is of so much value. The drawbacks to its exclusive use in health, which we pointed out above, are now of no account or are even converted into advantages. The use of milk in the dietary of different diseases will be considered in detail in a subsequent chapter, but some of its general properties may be mentioned here.

Being a fluid, it is easily swallowed. This is a great gain to exhausted patients. For the same reason the quantity given can be simply regulated and measured. Its fluid form also enables it to be used in place of other beverages and a glass of milk with each meal is one of the simplest prescriptions for increasing the amount of food a patient is taking. It is often recommended to people who require to be fattened.

The amount of water it contains makes milk a means of quenching thirst as well as of supplying food. It is therefore grateful to feverish patients.

Its bulk is no serious drawback in most illnesses. A patient at rest and warm in bed requires much less food than an active man and may even gain weight on 3 or 4 pints of milk per day, although more than twice that quantity may be requisite when up and about. In addition to this, concentrated foods are not so well borne in severe disease and a moderate degree of dilution is an advantage. Milk calls for less secretory effort and is more easily absorbed than any other food and this marks milk as a food of special value in gastro-intestinal disorders. To these advantages are added the facts that milk contains none of the "stimulating" substances found in meat and no purine bodies. From the earliest times

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[1] ORR. (1928), *Brit. Med. Journ.*, **1**, 140; (1929), *ibid.*, **1**, 161.

(Hippocrates, Galen, and Celsus) milk has been regarded as a sovereign remedy. Amongst mediæval writers, Van Swieten and Hoffman recognized its great virtues, whilst its most strenuous advocate in more modern times was Karell,[1] who used it in the treatment of dropsy, asthma, neuralgias of intestinal origin, and cases of malnutrition. Donkin also did much to make its virtues known, while in later years it attained prominence as an important part of the Weir-Mitchell treatment.

It is said that milk causes constipation, and it is true that this is apt to occur in patients taking large amounts. These patients are usually in bed and it seems probable that the constipation is really due to the rest in bed rather than to the milk itself, since many people not taking milk are apt to have difficulty in keeping the bowels open while lying in bed.

It must always be remembered that some people are unable to take milk since they are milk sensitive, and suffer from vomiting and diarrhœa if they drink it. Milk should never be forced on such patients. Others, however, dislike it, although it does not make them ill. It is possible to persuade these patients to drink it if the taste is disguised with tea, coffee, chocolate or cocoa, or if it is given in the form of a junket or with rice, etc., as a milk pudding. The milk can also be flavoured with pepper and salt as in bread sauce, and a pinch of salt added to a glass of milk is sometimes of value, but it is usually difficult to persuade these patients to take much milk by these methods.

FOODS DERIVED FROM MILK

Whey. We have already learnt that ***whey*** is the fluid which exudes from clotted milk. It is best prepared by adding to 30 oz. of milk heated to 104° F. two teaspoonfuls of rennet, and setting aside in a warm place till clotting has occurred. The clot must then be broken up very thoroughly by stirring, and the whole strained through muslin. About 22 oz. of whey should be obtained with (approximately) the following composition :

COMPOSITION OF WHEY

Water	93·64	per cent.
Protein	0·82	„
Fat	0·24	„
Lactose	4·65	„
Mineral elements	0·65	„

Whey can also be made by precipitating the caseinogen by means of an acid—e.g. a sour wine. It is in this fashion that ***white wine***

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[1] KARELL. (1866), *Edin. Med. Journ.*, 12, 97.

whey is prepared. ***Alum whey*** is a similar product. A desiccated whey is made under the name of Secwa.[1] It contains all the constituents of whey in a sterile and soluble form, and is a very convenient and useful preparation.

Whey, as its composition indicates, is a fluid of but small nutritive value. It hardly ever enters into an ordinary diet, but is often an aid in the feeding of infants. It has slight laxative properties, and should be avoided when there is any tendency to diarrhœa.

The so-called ***whey cure*** is a means of treatment sometimes resorted to in cases of dyspepsia, especially when occurring in gross feeders ("abdominal plethora"). Its range of usefulness is much the same as that of the grape cure, and, as in it, large allowance must be made for the favourable influence of the open air and exercise which form a part of the régime. The quantity of whey consumed is at first limited to a tumblerful night and morning, but the amount is gradually increased until a maximum is reached of ten tumblerfuls per day. The only other foods allowed are vegetables and fruits.

It once was used in the treatment of typhoid fever and as its Calorie value is very small, was responsible for the great loss of weight which occurred. Whey is little if ever used nowadays in the treatment of disease.

Cream consists essentially of the fat of milk. It would be a mistake, however, to suppose that it consists of that alone. It contains in addition protein and sugar in nearly as high proportion as milk itself.[2] The main difference, indeed, between milk and cream is that in the latter some of the water of the milk has been replaced by fat.

The exact amount of fat in cream varies very much, the differences depending to a large extent on the method by which the cream has been separated. In cream produced by a centrifuge the proportion of fat may amount to 65 per cent., while in ordinary cream, obtained by skimming, it may be merely 20 per cent. or less. The average amount of fat in specimens of centrifugal cream examined by Droop Richmond was 48·9 per cent. In 716 samples obtained from the London market Vieth found an average of 45½ per cent. for single and 53½ for double cream. There is no legal standard of composition for cream, but in the Annual Report of the Ministry of Health (1922) it is stated that "it is fairly generally accepted in this country that cream (i.e. raw dairy cream) should contain 40 to 50 per cent. butter fat."

[1] Casein, Ltd., Battersea, S.W.11.

[2] Cream contains about 1·8 per cent. of protein, 42 per cent. of fat, 2·4 per cent. of lactose, and 0·059 per cent. of calcium.

The well-known ***Devonshire, Cornish or clotted cream*** is a special variety prepared by heating the milk in deep pans, which causes a rapid and very complete separation of the fat. The proportion of fat in such cream is not far short of 60 per cent., as is shown in the following analyses : [1]

COMPOSITION OF CLOTTED CREAM

Water.	Protein and Sugar.	Fat.	Ash.
1. 32·48	8·60	58·21	0·71
2. 35·54	6·80	57·09	0·57

In a physiological sense, cream is chiefly to be regarded as a fuel food. It has been calculated that a pint of it should yield about 1425 Calories, or about as much as 1⅛ lb. of bread or 1½ dozen bananas or 4½ lb. of potatoes.

In sick-room feeding it is an important aid in getting fat into the diet, for it is very easily digested. Good cream (45 per cent.) contains as much fat as a similar quantity of most cod-liver oil emulsions, and is usually much better borne.

Cream, however, is by no means an economical source of fat. One and a half pints of it do not contain more fat than 1 lb. of butter, and cost about three times as much.[2] Cream, therefore, is to be regarded as a luxury.

Ice Cream. This substance, though universally used in the United States in dietetics, is at the present time only beginning to make its way in this country. There is still a strong prejudice against its use based partly upon its very questionable bacteriology and partly upon the theory that it is dangerous to digestion. On the first score there is some reason for suspicion. There is no regulation in this country governing its composition, nor the permissible number of microbes. Of 237 samples taken by Bardsley,[3] 216 contained enterococci and 209 coliform bacilli and the arithmetic mean of the number of bacteria per cubic centimetre for the samples containing coliform bacilli was 2,000,000.

None the less, with well-controlled manufacture there is no reason at all why a sound and nutritious ice cream should not be on the market. What dietitians need is a standardized substance of known composition, but at present, if they use it, they must make it themselves.

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[1] DROOP RICHMOND. SCHALL gives Protein 4·4, Fat 57·4, Cbo. 2·0.

[2] By the Cremac process cream can be made from butter by melting the latter with a little milk and re-emulsifying the fat. The product is much cheaper than ordinary cream, i.e. about 1*s*. 1½*d*. per pint against the 2*s*. 6*d*. to 3*s*. 6*d*. usually charged.

[3] BARDSLEY. (1938), *Journ. Hygiene.*, 38, 527.

A good average ice cream[1] contains:

Fat	12·5 per cent.
"Serum solids" (i.e. caseinogen and lactalbumin)	10·0 „ „
Sugar	16·0 „ „
Gelatin	0·25–0·50 „ „
Egg yolk solids	0·50 „ „

British manufacturers of ice cream aim at a fat content of 8–12 per cent. and make their "cream" from skimmed milk powder, unsalted margarine, sugar, gelatine and dried whole egg. There should be little difficulty in making a fairly sterile food from such substances. An 8 per cent. mix yields about 5 grammes C., 1·25 grammes P., 2·4 grammes F. and 47 Calories per oz.[2]

As ice cream has practically no satiety value, is a source of Calories and first-class protein and is used widely in the United States practice of dietetics after operations on the tonsils and alimentary tract and in fevers, it is here recommended to the consideration of dietitians in Great Britain, with the proviso that its bacteriology must be controlled.

Butter and margarine which certainly can be regarded as milk products are dealt with earlier under foods used for their energy value. Their content of protein, though first class, is negligible.

Butter-milk. This is the fluid left after the fat has been removed from soured cream by churning. Its sourness is due to the presence of lactic acid, of which, however, it does not usually contain more than $\frac{1}{4}$ to $\frac{1}{3}$ per cent. Its general composition is shown in the following analyses:

COMPOSITION OF BUTTER-MILK

	Protein.	Fat.	Carbohydrate.	
1.	3·0	0·5	4·8	Atwater
2.	2·37	0·4	3·79	Dunlop
3.	3·7	0·7	3·7	Schall

The chief point in which it differs from milk is its poverty in fat, in which respect it resembles skimmed milk. The loss of milk sugar by the formation of lactic acid is too small to be of any significance.

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[1] SOMMER. (1938), *The Theory and Practice of Ice Cream Making.* 3rd edn. Published by the Author, Madison, Wisconsin, U.S.A. 26*s.*

[2] *Food Manufacture.* (1945), **20**, 48.

Butter-milk is very easily digested, owing to the absence of fat and to the fact that its casein is present in a finely flocculent form.

Its nutritive value is considerable, an ordinary glassful yielding about as many Calories as 2 oz. of bread. It is as a cheap source of protein, however, that butter-milk is chiefly deserving of notice. In respect of this constituent, it is not one whit inferior to ordinary milk, and yet butter-milk is usually thrown out to the pigs. There can be no question that there is here a great waste of a very valuable food. When used in large quantities, butter-milk has diuretic properties which may be a slight disadvantage in health, but would rather enhance its value than otherwise in many cases of disease.

SOURED MILKS: KEPHIR, KOUMISS, ETC.

The preparation of these milks is dealt with elsewhere and a more detailed account will be found in an earlier edition. Apparently little interest has been taken in these commodities for years in the analytical world. We append analyses as quoted in earlier editions and in Schall.

	Protein.	Fat.	Lactose.	Alcohol.	Mineral Elements	Lactic Acid.
Koumiss (Rubner) .	2·2	2·1	1·5	1·7	0·9	0·9
Kephir (Rubner) . .	3·1	2·0	1·6	2·1	0·8	0·8
Butter-milk (Rubner) .	3·8	1·2	3·3	nil	0·6	0·3
Yoghurt (Schall) . .	3·3	2·8	3·1	nil	not given	0·8

These substances are reputed to be more digestible than the respective milks from which they arise. The caseinogen is in a fine flocculent form. The carbon dioxide in the fermented drinks (Koumiss and Kephir) is supposed to break up the curd in the stomach. The alcohol is not enough to cause more than a mild hilarity, with no subsequent headache. And the taste is pleasant to those with a conditioned reflex for it.

There can be no harm in taking it and though we know of no recent instance in which its use has proved of advantage it has been recommended as of value in "all conditions of impaired nutrition, in continued fevers and in convalescence. It may also be used . . . in chronic catarrh of the stomach or bowels, in cases of hepatic cirrhosis, and in renal disease. It is often better borne in vomiting than any other form of food and has been recommended in delirium tremens." [1]

Casein Preparations

In practical dietetics, the want of a tasteless, compact, easily digested and moderately cheap preparation of pure protein is often felt. Caseinogen is admirably adapted to meet these requirements, and has now been separated from milk and introduced as a dietetic preparation on its own account. The preparations known as Plasmon, Casumen, etc., are examples of caseinogen prepared in various ways. They contain about 80 per cent. of protein.

In these forms caseinogen is digested with ease and absorbed almost in its entirety, and is capable, if necessary, of replacing all other forms of protein in the diet. Added to this, caseinogen presents some special advantages not possessed by other varieties of protein. For one thing, it is readily capable of "fixing" acids, and so neutralizing them. The power of caseinogen in this respect is three times greater than that of an equal weight of beef. This property gives it special advantages in those cases of dyspepsia in which too much acid is being poured into the stomach.

Caseinogen is a phosphoprotein, contains all the essential amino-acids though its content of cystine and methionine is low, is easily digested and absorbed. It forms no clot in the stomach. Its main defect is that it contains but little calcium, though much phosphorous, for it is usually prepared by acid precipitation and not by rennin.

The nutritive value of these preparations of caseinogen is undoubtedly very high, for they contain fully 80 per cent. of pure protein. An invalid does not require more than 80 grammes of protein daily, and this quantity would be covered by 100 grammes (3½ oz.) of Plasmon or Casumen. That an amount almost equal to this can be administered daily for prolonged periods has been fully proved by clinical experiment.

It is as a means of enriching the diet in protein, rather than as sources of energy, that these preparations are specially valuable. Roughly speaking, one may say that one part of them is equal as a source of protein to four parts of meat. Their tastelessness and solubility enable them to be added to other foods, such as soups, milk puddings, cocoa and jellies, raising greatly their nutritive value, and without the patient's being aware that any such addition has been made. In many cases of illness, and especially, perhaps, in fevers, they increase very considerably our dietetic resources, and have taken an important place in treatment. They are superior to meat preparations as condensed forms of protein.

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[1] *Food and the Principles of Dietetics.* Eighth Edition.

There are various preparations of caseinogen combined with glycerophosphate of sodium on the market (Sanatogen, Kemposan, Nervogen). In virtue of their casinogen these have the same nutritive value as the other preparations considered above. The organic phosphorus in them appears to be fully assimilated. It may be doubted, however, that they have a "specific tonic effect on the nervous system".

Cheese

Of cheese there is an infinite variety. They have this in common: they contain the casein, some or all of the fat, the vitamin A, the calcium and phosphorus and some of the vitamins B_1 and riboflavine of the milk from which they are made. The majority are made from cows' milk, but some are from goats' and ewes' milk. Cheese is a mode of preserving much of the food value of milk in a condensed form for long after the milk from which they are made would be unfit for consumption. For example, Cheshire cheese is at its best about a year after it is made. Because of the strong flavours developed in cheeses under the influence of bacteria and moulds, cheese is often regarded more as a condiment than as a staple food, but this is to be deprecated. Cheese is one of the most valuable foods there is and is a most convenient way of spreading the excess of milk in early summer in a concentrated form over the whole year.

It is prepared mainly in two ways. Milk, with or without pasteurization, is directly treated with rennet to produce a clot, or the milk may first be soured by means of a starter after pasteurization and then clotted with rennet. The first way produces a sweet curd and the second an acid curd. Cheeses from an acid curd have much better keeping qualities. Stilton is an example of sweet curd cheese, and Cheddar and Roquefort of acid curd cheeses.

Instead of using a starter, the milk may be allowed spontaneously to sour or acids added to bring down the caseinogen. In all cases the casein clot or caseinogen curd entangles the fat. The milk may be enriched by the addition of cream (Stilton) or it may first be skimmed, in which case the fat content of the cheeses will be low and the protein percentage increased (Dutch and German cheeses). So even at the first stage of cheese-making individual variations of the finished product are instituted. Where starters are used it is important to control the nature of the bacteria they contain—usually streptococci lactis or cremoris—for they are susceptible to invasion by bacteriophage, which slows the production of acid and this effects a loss of keeping quality and flavour.

After the clot has fully formed it is cut with special knives. This liberates the whey from the curd, and the mass may be both stirred and warmed, allowed to settle and the whey run off. The curd is eventually ground in a mill, salted and put into moulds. The remainder of the whey may be squeezed out under pressure. This produces a *hard cheese*, e.g. Caerphilly, Cheddar, Cheshire, Gloucester, Parmesan. But where the whey drains out under the natural weight of the curd, a soft cheese results, e.g. Camembert, Gorgonzola and Stilton. The soft cheeses do not keep well and are intended for early consumption, the hard cheeses are at their best in the course of a year. The soft cheeses are of an open texture and moulds from the air make their way into the interior (Stilton, Blue Vinny, Rocquefort and Gorgonzola). This is often aided, even with Stilton, by pricking the cheese, e.g. Roquefort. The amount of salt, the time at which it is added and the date of pricking also determine the rate and mode of ripening and the differences between Roquefort and Danish Blue on the one hand and Stilton and Gorgonzola on the other. From the lactic acid present in the curds and from the fat, volatile fatty acids are formed (acetic, propionic, butyric and caproic), and also from the fat higher non-volatile fatty acids. These help to determine the flavour. Sharpness is due to acetic and propionic compounds, cheesiness to butyric and valeric compounds and pungency to caproic, caprylic and capric bodies. Moreover, there is degradation of the protein, with ammonia production, which adds to the flavour of the cheese. In view of the varied nature of the processes by which cheese is made and the complexity of the biological and chemical reactions within the cheese as it ripens, we can understand the reason why there is such an infinite variety of cheeses and why even cheeses of one type vary so much one from another. This has been particularly noticeable in war-time " cheese " which has often been inefficiently made and rushed on to the market before it had achieved a venerable ripeness.[1]

The value of cheese in nutrition is judged by its content of protein, fat, calcium, phosphorus and vitamin A. The following analyses are taken from McCance and Widdowson : [2]

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[1] For the technology, bacteriology and flavour of cheeses a number of papers given to the Food Group of the Society of Chemical Industry should be consulted. KAY. (1941), *Chem. and Ind.*, **60**, 411 ; HISCOX. (1941), *ibid.*, **60**, 563 ; MEANWELL. (1943), *ibid.*, **62**, 73 ; WAYGOOD. (1943), *ibid.*, **62**, 59.

[2] *Chemical Composition of Foods.* (1942), *Med. Res. Council Special Report*, No. 235. Third Edition.

	Protein.	Fat.	Carbo-hydrate.	Cal-cium.	Iron.	Phos-phorus.	Calories per oz.
				mg.	mg.	mg.	
Cheddar . .	24·9	34·5	trace	810	0·57	545	120
Cream (home-made) . .	3·2	86·0	„	29·6	0·14	44	232
Dutch . .	28·1	16·8	„	900	0·78	478	77
Gorgonzola .	24·8	31·1	„	540	0·50	375	112
Gruyère . .	36·8	33·4	„	1080	0·26	698	131
"Packet" .	22·5	30·1	„	724	0·57	480	106
Parmesan. .	34·4	29·7	„	1220	0·37	772	118
St. Ivel . .	23·1	30·5	„	483	0·72	375	108
Stilton . .	25·1	40·0	„	362	0·46	304	135

The vitamin A potency of "cheese" (i.e. Cheddar type) is given by the Medical Research Council as 1300 I.U. per 100 grammes, the vitamin B_1 as 30 microgrammes (or 10 I.U.), and riboflavine as 500 microgrammes. These are average figures and vary with the source of the milk and the time of the year. Kay,[1] comparing Cheshire cheese made from winter milk with that from summer milk, showed that the former gave only about 700 I.U. vitamin A activity per 100 grammes while the summer milk cheese yielded approximately 1500 I.U. The relatively high amounts of riboflavine which he found in winter and summer milk cheeses (280 microgrammes and 350 microgrammes respectively) must be due to a combination of protein with the riboflavine. The low figures for calcium and phosphorus in Stilton cheese is due to the removal of those substances by the lactic acid of the whey which is allowed to bathe the curd for a long time. A large proportion of the calcium and phosphorus of Stilton migrates to the crust, is deposited there, and when the cheese is eaten is thrown away with the crust.

Digestibility. The infiltration of cheese with fat must always render it an article of diet not easily dealt with by the stomach, for the fat forms a waterproof coating, which prevents the access of the digestive juices to the casein.

The larger the lumps of cheese which reach the stomach, the slower will this access be. Hence the importance of reducing the cheese to a state of fine division before it is swallowed. This may be done by careful chewing. Now, it is more easy to pulverize a hard morsel than a soft one, for the latter always tends to elude the teeth. For this reason, a piece of hard, dry cheese is more easily

[1] KAY. (1941), *Chem. and Ind.*, **60**, 411.

digested than a soft and moist piece. A better plan, however, is to break up the cheese before it is eaten. This may be done by grating, and so successful is this that it can be given in this form to infants of nine months of age!

A possible reason for its reputed indigestibility is that it is taken at the end of a meal and its strong odour flavours any subsequent eructations. Any other highly flavoured food would do the same.

It is only in the stomach that the difficulty of digesting cheese occurs; once in the intestine, it is absorbed very thoroughly, over 90 per cent. of the protein being retained in the body, and nearly 90 per cent. of the energy it contains being "available."[1]

Nutritive Value. Of the high nutritive value of cheese there can be no doubt. It is just what would be expected when one remembers that a pound of, say, Cheddar cheese represents the total casein and vitamin A, most of the fat and calcium, and a quarter of the riboflavine in a gallon of milk, or 2 oz. cheese results from 1 pint of milk.

The average amount of moisture which cheese contains is 33 per cent., the remainder being made up of protein and fat in varying, but on the whole fairly equal, proportions. The amount of water in moderately lean beef is about 73 per cent., the remainder being also made up of protein and fat, the former usually predominating.

Beef, then, contains less than half as much nutriment as the same weight of cheese. It has been calculated that a cheese of 20 lb. contains as much nutriment as a sheep's carcase of 60 lb. Moreover, cheese is almost the best source of calcium and phosphorus. A vegetarian who took all his animal protein as milk and cheese had the large amount of 2 grammes of calcium per day in his diet.[2]

An appeal to the standard of the Calorie gives the same verdict. A pound of cheese yields nearly 2000 Calories of energy, which is more than three times the amount yielded by a pound of moderately lean beef. Furthermore, a pound of cheese can be obtained at about one-quarter of the cost of 3 lb. of beef, which is its nutritive equivalent, and therefore it is at once evident that cheese is a substitute for meat which should be of the greatest value in poor households.

But if cheese is thus to become a cheap substitute for meat, it is of the greatest importance what variety of cheese is bought. For it is true of cheese in an even greater degree than of most other foods, that in buying it we pay for flavour, not for food value. In the

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[1] U.S. Dept. of Agriculture. Farmers' Bull., No. 487.

[2] Widdowson. (1936), *Journ. Hygiene*, **36**, 269.

9th edition this point was driven home by the calculation of the cost per unit of nutriment obtained from different cheeses, but as many of those listed will not be procurable for many years to come, it would be useless to quote or attempt to recalculate them now. It must suffice that in 1939 the cost ranged from 1*s.* 4½*d*, for "American" Cheddar to 4*s.* 2*d.* for St. Ivel. This high price for flavour and convenience is particularly marked in the cheese labelled "packet" cheese in the table given above. These cheeses are usually manufactured from matured cheeses of the Cheddar type which have been milled, melted and mixed with milk and the whole pasteurized. They have an individual flavour, constant texture and remarkable keeping quality.

Finally, the biological value of the protein in cheese is high, though not as high as that of the mixed proteins of milk. Henry and Kon[1] obtained by the method of Mitchell a biological value of 75·6 for the proteins of Cheddar cheese and demonstrated a marked supplementary relationship between them and those of white bread. But to show that supplementary action they must be taken together—as indeed is the usual custom!—and not separated by 24 hours. Moreover, the proteins of cheese contain valuable amounts of the important amino-acid, methionine.

Cheese, then, is a food the consumption of which is to be encouraged, not as a condiment or savoury at the end of a meal, but as a *pièce de résistance.* It is portable, compact and highly nutritious. 4 oz. cheese, 8 oz. of National Wheatmeal bread and 2 oz. watercress form an almost nutritionally complete meal. Only vitamin D is missing, though its precursor, cholesterol, is present, and it yields 1000 Calories. During the war of 1939–45 the agricultural labourer has been allowed a ration twice or more as large as the normal individual—a welcome recognition by the Ministry of Food of its value in diet. Oddly enough, taste varies markedly in different parts of the country and in different strata of society. The Welsh miner, for example, readily consumes cheese, but the Durham miner will not touch it. There is room for propaganda in favour of cheese.

Fish[2]

Chemical Composition.—Protein and fat are the chief nutritive constituents found in fish. According to the relative proportions of these ingredients present, fish may be conveniently divided into two groups of "fat" and "lean."

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[1] Henry and Kon. (1942), *Chem. and Ind.*, **61**, 97.

[2] In preparing this section the writers have derived much help from the following publications: Atwater, W. O. (1891), *The Chemical Composition and Nutritive Values of Food Fishes and Aquatic Verte-*

The fat fish have considerable amounts of fat in their flesh, say from 10 per cent. upwards. They are bloaters, eel, herring, kippers, salmon, sardines, sprats and whitebait. The lean fish have almost negligible amounts of fat, say about 1 per cent. or under. They are cod, flounder, haddock, John Dory, lemon sole, ling, megrim, monkfish, plaice, pollack, saithe, sole, stockfish, turbot and witch. It is true that there are some with intermediate amounts, such as bass, bream, brill, catfish, gurnet, hake, halibut, mackerel, mullet, pollan, sturgeon and trout, but the amount of fat is rarely as high as that of lean meat.

Analyses of some of the commoner varieties are here given:

Composition of Fish (Raw) (Plimmer)

	Protein.	Fat.	Calories per oz.	Carbohydrate.
Cod	14·6	0·1	17	0
Eel	8·7	15·1	50	0
Haddock	12·0	0·2	14	0
Herring	14·6	8·8	40	0
Mackerel	11·0	6·2	29	0
Plaice	7·7	0·7	11	0
Salmon	14·7	12·5	50	0
Smelt	11·3	1·6	17	0
Sole	13·0	1·3	19	0
Turbot	8·8	1·3	12	0
Whiting	11·3	0·1	12	0

When steamed or boiled there is a considerable concentration of nutrient material, for the protein shrinks in volume and squeezed-out water. This is evident from the following table based on McCance and Shipp,[1] though the figures are not quite comparable, being obtained by different methods and from materials from a different part of Great Britain.

[1] *op. cit.*

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brates, Washington (abstract from Report of U.S. Commissioner of Fish and Fisheries, 1888); Langworthy, C. F. (1898), *Fish as Food*, U.S. Dept of Agriculture, Farmers' Bull. 85; McCance, R. A., and Shipp, H. L. (1933), *The Chemistry of Flesh Foods and their losses on Cooking, Med. Res. Council Special Reports*, No. 187; McCance and Widdowson. (1942), *The Chemical Composition of Foods, Med. Res. Council Special Reports*, No. 235, 3rd edn.

Analysis of Flesh of Cooked Fish

	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Phosphorus.	Calories per oz.
				mg.	mg.	mg.	
Cod, steamed . .	18·0	0·9	0	14·6	0·5	242	23
Eel, stewed . . .	11·0	18·1	0	41·7	1·2	137	60
Haddock, steamed.	22·0	0·8	0	54·6	0·7	234	28
Halibut ,, .	22·7	4·0	0	13·0	0·6	255	37
Herring, baked .	16·9	12·9	0	58·2	1·6	326	54
Plaice, steamed .	18·1	1·9	0	37·7	0·6	246	26
Salmon, ,, .	19·1	13·0	0	28·9	0·8	302	57
Sole, ,, .	17·6	1·3	0	113·0	0·7	270	24
Turbot, ,, . . .	20·7	1·6	0	13·5	0·5	188	28
Whiting, ,, .	19·9	0·9	0	42·0	1·0	189	26

To these may be added some analyses of preserved fish.

Preserved Fish, as purchased

	g. per 100 g.			mg. per 100 g.		Calories per oz.
	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	
Bloater	12·6	10·5	0	84	1·4	41
Cod, hard, dried .	27·3	1·0	0	43	1·6	34
Haddock, smoked	9·9	0·3	0	47	0·6	12
Kipper	11·4	16·0	0	72	1·2	37

Preserved Fish, as served

	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Phosphorus.	Calories per oz.
Bloater, grilled . .	22·6	17·4	0	123·0	2·2	355	73
Cod, dried, soaked 24 hours and boiled	32·0	0·9	0	22·4	1·8	163	40
Haddock, smoked, steamed . . .	22·3	0·9	0	57·5	1·0	248	28
Kipper	23·2	11·4	0	64·8	1·4	426	57
Salmon, tinned . .	19·7	6·0	0	66·4	1·3	285	39
Sardines ,, . . .	20·4	22·6	0	409·0	4·3	683	84

The points in the composition of fish deserving of comment are these :

1. There is a large amount of waste, in the form of bones, skin, etc. As sold, the waste may be as much as 70 per cent., while even in fish as served at table it may be 35 per cent. This increases its cost in transport when compared with meat.
2. Fish, especially the leaner varieties, have a high water content—considerably more than lean meat.
3. Fish contains more gelatin than meat, and this is largely lost when fish is boiled—a reason why this method of cooking is by no means advantageous.
4. Fish is poor in extractives and lacks flavour compared with meat, and so a fish diet is apt to prove monotonous.
5. The Calorie value of fish is low, except in the fat fish.
6. Fish is a good source of protein, though not so good as meat or cheese.
7. With the exception of sole and of those fish in which it is impossible not to eat some of the bones (bloaters, herring, kippers, sardines, sprats and whitebait), fish is a poor source of calcium, though an excellent source of phosphorus.
8. Their content of purine bodies run as high as, or higher than, those of meat.

In spite of these drawbacks, when compared with meat, it forms a very valuable addition to our diet, and it is absurd that, with the methods of refrigeration at our disposal and the excellent fishing grounds near the coasts of the British Isles, such a source of good protein should be so difficult to obtain in most inland parts of this country. Moreover, fish is one of the best sources known of nicotinic acid, and the fat fish are a good source of vitamins A and D. Herrings and herring roes are the cheapest source of animal protein, and it should be the task of dietitians to stimulate a demand for fish and of enterprising firms to put fish on the market in a fresh condition. Fortunately the conditions for preserving the good qualities of fish have been worked out at the Torrey Research Association. Fish after six days' storage in an ordinary ship are stale and after twelve days when stored in ice. If fish are frozen in iced brine at − 4° F. and kept at that temperature they are still good after six months. White fish frozen at − 22° F., while still in *rigor mortis*, are more satisfactory at the end of eight months than most of the fish now sold on the open market. Herrings can be brought to freezing plants *on shore* while still fresh, can be stored there many months and then kippered or packed, obviating the difficulty of gluts. Finally, fish can be dehydrated and, when packed in containers filled with nitrogen, remain good for a year. The presentation of satisfactory fish and fish products to the public is a question of organization and capital.[1]

Digestibility of Fish. The white or lean fish are reputed to be digestible, whereas the fat fish are not. There is no doubt that they are easy to chew, have but very short bundles of muscle fibres and when cooked fall easily to pieces. They are consequently used in the diet of the very young, the very old, the dyspeptic, and the convalescent.

None the less, experiment is not so very much in favour of their extreme digestibility. Hawk, Rehfuss, and Bergeim in 75 observations on the normal human stomach find that while fish evoke a slightly greater flow of acid they leave the stomach but slightly faster than beef and beef products.[2] For the present we must rely more on clinical observation than upon scientific experiment. It is strongly in favour of the digestibility of the white fish. Cod seems to be an exception, having a coarse fibre, and its comparative indigestibility, as found by Chittenden and Cummins, is by no means in contradiction with actual experience (Pavy). The slow solution of salt fish is fully explained by the hardening of the fibres which salting produces.

The *absorption of fresh and smoked fish in the intestine* takes place quite as well as that of meat, about 95 per cent. of the total solids, 97 per cent. of the protein, and 90 per cent. of the fat entering the blood (Langworthy). Salted and dried fish are not quite so well absorbed.[3]

Nutritive Value of Fish. The value of fish as a source of energy depends entirely on the amount of fat which it contains. The fat fish, such as salmon, are fully equal to moderately fat meat in this respect, while the lean fish, owing both to the absence of fat and the presence of more water, are of considerably lower nutritive value. It may be reckoned that 2 lb. of cod or other white fish are only equal in nutritive value to 1 lb. of lean beef.

Fish can, however, be made to take up a considerable amount of fat in the process of cooking and so have its nutritive value greatly increased. This is shown in the following table :

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[1] See *The Problem of Supply of Sea Fish in an Industrialized Country.* (1944), *Food Manufacture*, **1v**, 347 ; and SHEWAN. (1945), *Chem. and Ind.*, 98.

[2] *Amer. Journ. Med. Sci.* (1926), **171**, **359**.

[3] SLOWTZOFF. (1910), *Zeit. f. Physik. und diät. Therapie*, **15**, **22**.

AVERAGE COMPOSITION OF EDIBLE PORTIONS OF 15 ASSORTED WHITE FISH, (1) STEAMED and (2) FRIED IN BATTER and BREADCRUMBS (MCCANCE AND SHIPP)

	Water.	Protein.	Fat.	Carbo-hydrate.	Calorie Value per Ounce.
(1) Steamed.	75·4	22·4	1·38	0·0	32·6
(2) Fried .	61·5	19·3	11·9	6·4	61·4

As a source of building material, fish is somewhat inferior to lean meat, owing to the smaller amount of protein which it contains. This statement applies more strongly to lean fish than to the fatter varieties. Owing to this smaller proportion of protein, and in part also, in all probability, to its lesser richness in extractives, fish seems to be a less stimulating food than meat. For the same reasons, white fish may sometimes be used with advantage instead of meat by sedentary persons, and in hot weather.

Two special qualities are erroneously attributed to a fish diet by popular fancy. We refer to the beliefs (1) that fish is specially valuable as a "brain food," (2) that it possesses aphrodisiac qualities. The false bases for these beliefs are dealt with in earlier editions of this work.

Economic Value of Fish. The market-price of fish is no indication of true economic value. Although such fishes as haddock and sole are of practically the same nutritive value, yet the price of the latter may be three times that of the former. On the other hand, it by no means follows that none of the dearer varieties of fish is worth the money. Salmon, for example, yields three times as many Calories as an equal weight of cod, and thus a pound of the former at 3*s*. 6*d*. may not really be any dearer than a pound of cod at 1*s* 2*d*. The amount of waste in fish is also of great importance from the economic point of view. We have seen that the inedible parts of fish as purchased may amount in some cases to as much as 70 per cent. of the whole, and allowance must be made for this in calculating the real cost. For this reason it may be worth while to pay a rather high price for canned fish, for in these preparations almost the whole of the material paid for is in an edible form. It is a matter for exact calculation.

As a general rule, it may be said that the cheaper varieties of the fat fishes offer most nutriment for any given sum. Salted white fish probably rank next to these. An average herring contains about 15 grammes of edible protein (½ oz.) and from 5 to 10 grammes of fat, and it has been remarked that the despised bloater "offers the largest amount of nutriment for a given sum of any animal food,"[1] and three salt herrings contain as much animal protein as need enter the daily dietary of an ordinary working man.

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[1] This is not quite true. Fresh herring and herring roes run a neck and neck race with Australian and New Zealand cheese in peace-time for cheap animal protein.

The justice of these remarks is borne out by the following calculations:

COMPARATIVE COSTS OF PROTEIN AND ENERGY AS FURNISHED BY DIFFERENT KINDS OF FISH

	Cost per lb.[1]		Cost per ration of First-class Protein.[2]		Cost per 1000 Calories.[2]	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
Cod (section) . .	1	0	0	6¾	3	7½
Haddock (fresh) . .	0	10	0	6¾	3	7
Hake	1	4	0	11	5	5½
Halibut . . .	1	6	0	11	6	5
Herrings . . .	0	6	0	3½	0	9¼
Mackerel . . .	0	7	0	9¾	1	3
Salmon . . .	3	0	1	8	3	9
,, (Newfoundland)	1	8	0	11	2	1
Soles	2	2	1	4½	7	2½
Turbot . . .	2	4	2	6	10	8

The relative cheapness of cod, haddock, and herrings for protein and of herrings for Calories will be manifest; otherwise fish are moderate to expensive for protein and extravagant for Calories.

Of the "offal" of fish, the ovary, or ***roe***,[3] is alone commonly eaten. The roe of the sturgeon, when highly salted, constitutes caviare, the best forms of which come from Astrachan. Good ***caviare*** should be of a greyish colour—not black—and one should be able to make out the separate eggs in it quite easily. It is packed in vessels made of lime wood, as it is very apt to take up foreign flavours, and of these lime wood is destitute. The composition of caviare is as follows (Langworthy):

Water	38·1 per cent.
Protein	30·1 ,,
Other non-nitrogenous matters . .	7·6 ,,
Fat	19·7 ,,
Mineral elements	4·6 ,,
Fuel value per lb.	1530 Calories

The proteins contain a good deal of nuclein, the significance of which as an article of diet has already been mentioned (p. 254).

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[1] These are 1939 prices at a high-class store. The figures will have to be recalculated so soon as prices settled to a new level after the war. It is unlikely, however, that the relative positions will change greatly, though the actual figures undoubtedly will.

[2] Calculated on Plimmer's Analyses.

[3] Usually called the "hard roe."

Three ounces of raw salted caviare are digested in the stomach in about two hours.

The ***milt***[1] is the organ in male fish corresponding to the roe, and resembles the latter very closely in composition and nutritive value. Plimmer's figures for the herring soft roe are: Protein 26·0 per cent., Fat 3·6, Mineral elements 3·9, Calories per oz. 40.0 McCance and Widdowson's figures for fried roes are Protein 23·4, Fat 15·8, Carbohydrate 4·7, Calcium 15·7 milligrammes, Iron 1·5, Phosphorus 915 milligrammes, Calories per oz. 74. (The roes were rolled in flour before frying.) The milt, however, is much richer in purines. (Purine N in herring milt is 0·484 per cent.).[2]

The lobster, crab, and other crustaceans, the molluscs, such as the oyster and mussel, and the turtle and frog amongst reptiles and amphibians, may conveniently be considered at this point.

The ***lobster and crab*** both consist of two distinct parts: the flesh, which is contained in the claws and tail; and the body, which is mainly made up of liver. The general composition of these parts is thus contrasted by Payen:

PERCENTAGE COMPOSITION OF LOBSTER AND CRAB

	Flesh.	Body.
Water	76·6	84·31
Protein	19·17	12·14
Fat	1·17	1·14

COMPOSITION OF TINNED LOBSTER (Langworthy)

Water	77·8 per cent.
Protein	18·1 „
Fat	1·1 „
Carbohydrates	0·6 „
Mineral elements	2·4 „

The composition of the crab and the prawn is practically the same.

The flesh of the lobster and crab is rather indigestible, mainly on account of the density and coarseness of the fibres and the thickness of their walls. The use of vinegar helps to soften the fibres, besides neutralizing ammoniacal salts, which are apt to be present.

The body of these animals is also prone to disagree, not only from the fat which the liver contains, but also, because a number of unfortunate people are "sensitive" to their proteins and develop allergic diseases after eating them.

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[1] Usually called the "soft roe."

[2] Cod's roe purine Nitrogen is 0·130 per cent.

Three ounces of potted lobster require about two and a half hours for digestion in the stomach.

The *oyster* is the most typical and popular of the molluscs. Chemically it contains within itself representatives of all three nutritive constituents of the food :

Average Composition of Oysters (McCance and Widdowson)

Nitrogenous substances	10·2 per cent.
Fat	0·9 ,,
Carbohydrates	Trace ,,
Calcium	0·186 ,,
Iron	0·006 ,,

Glycogen is the form in which carbohydrate is present in oysters. It is contained in the liver. In addition, oysters are rich in vitamins and in mineral constituents, including iodine, iron, and copper.[1]

The oyster is rightly regarded as an easily digested food—at least, if taken raw. Three medium-sized oysters are entirely disposed of by the stomach in 1¾ hours. Cooking renders them tough and less easily digested.

The nutritive value of oysters is not high. A dozen Ostend oysters contain about 5 grammes of digestible protein and 1½ grammes of fat. It would take fourteen of them to contain as much nourishment as one egg, and 223 to equal a pound of beef (Stutzer). It is therefore not surprising to hear of enormous quantities of oysters being occasionally consumed at a sitting. They are an extravagant form of food, for a day's ration of first-class protein on Plimmer's analyses costs no less than £1 2*s*. 4*d*. when oysters are 3*s*. 6*d*. a dozen.

The belief that oysters may be the means of conveying the infection of typhoid fever is not unwarranted, for if oysters are grown in estuaries they easily enough become infected with typhoid germs derived from sewage, and it has been found by artificial inoculation that typhoid bacilli thus introduced are capable of surviving in the body of the oyster for several days.[2] The risk, however, can be avoided by keeping the oysters alive for a day or two in salt water which is frequently changed. This washes them out and destroys the bacilli. Cooking effects the same object with greater certainty, but at the cost of diminished digestibility. Modern English oyster beds are very carefully inspected and kept free from contamination.

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[1] L. Binet and M. V. Strumza. (1933), *Paris Med.* July 1st, 28. The iron is 6 milligrammes per cent. according to McCance and Widdowson, *op. cit.*

[2] Herdman and Boyce. *Lancashire Sea Fisheries.* Memoir I: "Oysters and Disease."

The composition of mussels, clams, periwinkles, scallops, and other molluscs is very similar to that of the oyster, and, like the latter, they cannot be regarded as foods of important nutritive value, though they do contain very significant amounts of calcium and iron. They rarely cause digestive disturbance, but unfortunately some people are sensitive to one or other of these shell fish. They may develop urticaria or they suffer from vomiting and diarrhœa. These latter symptoms are sometimes very severe and may cause death. It is possible that they are due to decomposition taking place as a result of storage.

The ***green turtle*** is almost the only reptile used for food in this country, and that chiefly in the form of soup. It is called green because its " fat " has a greenish colour, which, according to Sir Hans Sloane, imparts a yellow tint to the sweat of those who partake largely of it. In preparing the soup, the dorsal and ventral shields are removed, scalded to remove the scales, and then boiled till the bones separate. The liquor forms the stock. The softer parts of the shield are then cut into oblong pieces, which constitute the so-called lumps of green " fat "—really a species of cartilage. Sun-dried turtle forms a soup of equal nutritive value, and at a considerably lower cost, while the basis of mock-turtle is the gelatinous substance in the scalp of the calf. From a strictly nutritive point of view, turtle soup is certainly not worth a tenth of the price paid for it.

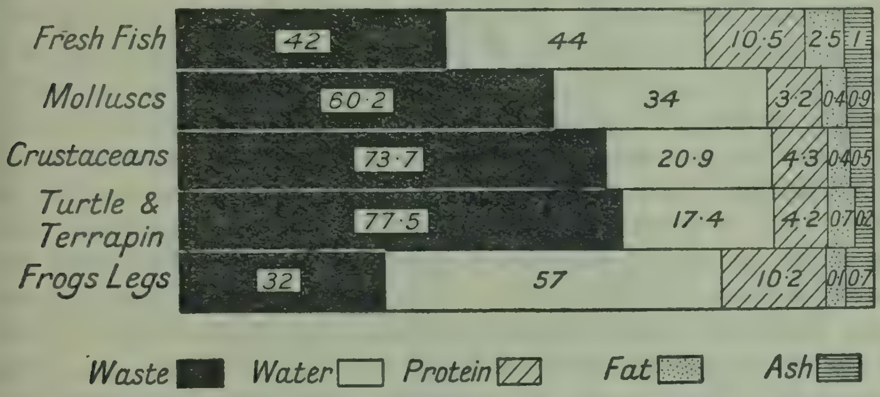

FIG. 20.—COMPARATIVE COMPOSITION OF FISH AND THEIR ALLIES.

Frogs' legs are but rarely seen in this country, though common articles of diet on the Continent and in the United States. They are derived from the large edible frog (*Rana esculenta*), and, though easily digested and of a delicate flavour, are not of high nutritive value.

The average chemical composition of the different groups of foods studied in this section is represented in Fig. 20, which also gives some idea of their relative nutritive values. It is constructed from the analyses published by Langworthy.

MEAT

Most of what we call meat is muscle—the muscles of the animal killed, which enabled it to "move and have its being." Even tripe is mainly muscle, and so is the edible portion of heart, though brain, liver and kidneys, of course, are not. This is no ground for believing that meat is especially good for the manufacture of human muscle though there may be something in this line of argument. The distribution and relative amounts of amino-acids in its proteins are very like those of human muscle.

Physical Structure. We may look first at the physical structure or architecture of meat (Figs. 21 and 22). If one examines a piece of boiled meat, it will be found that it can easily be torn into a number of long, stringy fibres. On microscopic examination, these are found to be made up in their turn of bundles of microscopic tubes, known to the histologist as muscle fibres. The bundles of fibres vary in length in different kinds of meat. Sometimes they are short, as in the breast of a chicken ; at other times they are much longer, as in the leg of a crab ; and the shorter they are, the more tender and easily digested the meat is. Meat should be cut or carved at right angles to the long axis of the fibres. It is then more easily chewed, and, the contents of the tubes being exposed, the flavour is increased, while the action of the digestive juices is facilitated.

The walls of the tubes consist of a protein substance (elastin), while the connective tissue which holds together the fibres is chiefly composed of a material called "collagen," which yields gelatin on boiling. The older an animal is, and the more work its muscles have had to perform, the denser is the connective tissue and the thicker the walls of the tubes. The latter fact was long ago pointed out by Dr. Kitchiner in his *Cook's Oracle*. "That exercise produces strength and firmness of fibre," he says, "is excellently well exemplified in the woodcock and partridge. The former flies most, the latter walks ; the wing of the woodcock is always very tough, of the partridge very tender ; hence the old doggerel distich :

> If the Partridge had but the Woodcock's thigh,
> He'd be the best bird that e'er doth fly."

Embedded in the connective tissue between the fibres is a variable amount of fat. Sometimes it is almost entirely absent—e.g. in most forms of game and in the breast of the chicken; at other times the amount of fat so placed is quite abundant. This is the case in pork, in highly-fattened beef or mutton, and in swimming birds, such as the duck and goose, which require a large store of fat, both to lighten the body and as a source of heat. A large amount of fat tends to diminish the digestibility of meat, apparently by forming a sort of waterproof coating around the fibres and hindering their solution by the gastric juice, and it is notorious that pork, duck, and goose are rather indigestible forms of flesh.

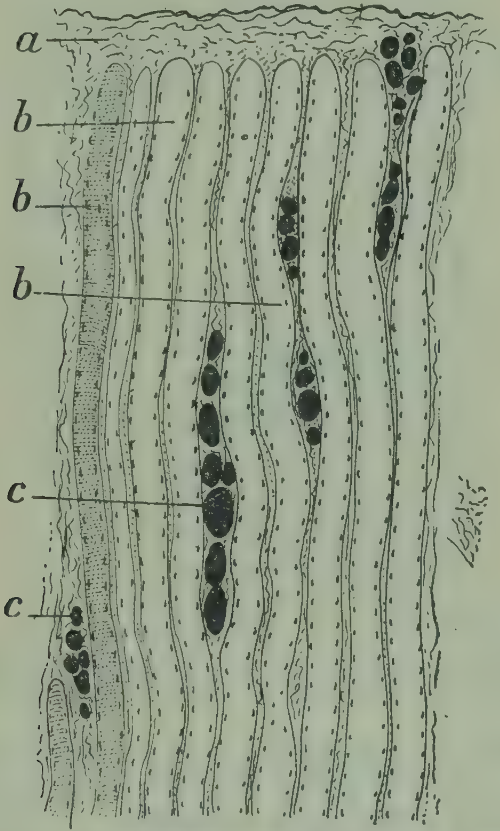

FIG. 21.—LONGITUDINAL SECTION OF A PRIMARY MUSCLE BUNDLE.
a. Connective tissue; *b.* muscle fibres; *c.* fat cells.

The ***contents of the microscopic tubes or muscle fibres*** consist of water holding in solution proteins, salts, and the substances known as "extractives," the whole constituting muscle-juice. The younger the animal, the more water does its flesh contain, and the lower is its nutritive value. This may be the explanation of the German saying, "Calf-meat is half-meat."

The chief ***proteins*** which the juice contains are myosin, myogen, globulin and hæmoglobin, the first being the most important.[1] Myosin has the property of clotting or gelation after death, the hardening of the muscle which results, being known, it will be remembered, as *rigor mortis*, or death-stiffening. Meat in that condition is tough, and accordingly, if tenderness is desired, the meat should be eaten either immediately after the animal is killed, and before *rigor mortis* has had time to set in, or else it should be allowed to hang till the rigor has passed off. The disappearance of rigor is due to a resolution of the gel by flocculation and breaking up of its structure.

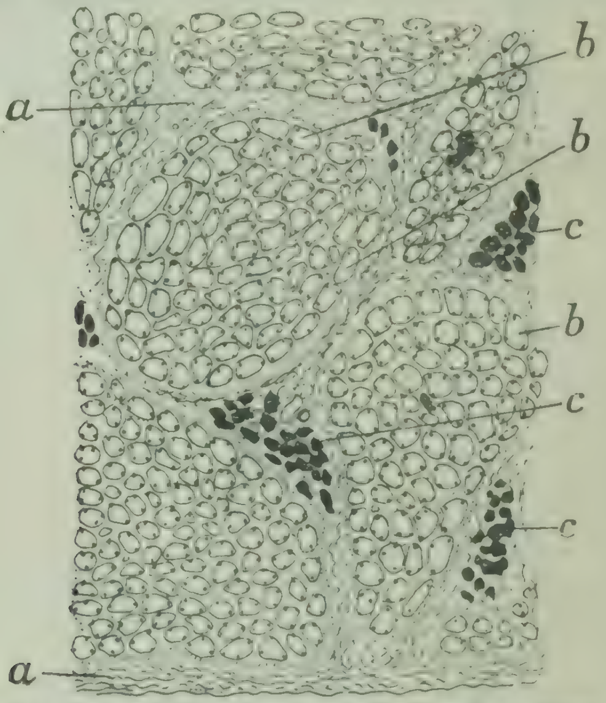

FIG. 22.—TRANSVERSE SECTION OF A NUMBER OF MUSCLE BUNDLES.
. Connective tissue; *b.* muscle fibres arranged in bundles (fasciculi); *c.* fat.

The *acids*[2] which develop in meat on hanging aid the gelatinization of the connective tissue which occurs on cooking, and also improve its flavour by removing the rather insipid flatness of taste which characterizes very fresh meat. In the flesh of animals which have undergone great muscular exertion immediately before being killed there is a considerable quantity of acid present, even at the time of death. Hence the flesh of hunted animals is of a superior flavour, and in less humane ages and countries attempts have been made to develop this flavour in domestic animals artificially by urging them to frantic exertions before slaughter. Another way of producing these effects by artificial means is by soaking the meat in vinegar and water for a short time. This is found to improve the flavour of fresh meat, as well as its tenderness.

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[1] Myosin, which appears to be a pure protein, represents 67·5 per cent. of the total intracellular protein; the myogen group, which is complex, about 10 per cent.; and the globulin X group, 22·5 per cent. BATE-SMITH. (1942), *Chem. and Ind.*, 373.

[2] Sarcolactic acid and acid phosphates. "Conditioning" of meat is mainly due to the effect of lactic acid on the collagen of connective tissue.

The amount of ***hæmoglobin,*** or red colouring matter, in the juice varies greatly in different kinds of meat, and is usually less in amount in that obtained from young animals. Whether its iron is " available " to the eater is doubtful. Hæmoglobin is also found in the small bloodvessels which form a network around the fibres of meat. In animals which have been bled to death it is much diminished in amount or altogether removed; hence the pallor of veal.

The chief ***inorganic substances*** found in the juice of meat are phosphates and potassium. There is very little calcium in meat.

Last, but not least, of the substances contained in solution in the juice of meat are the ***extractives.*** These are so called because they can be " extracted " from meat by means of boiling water, and are familiar to everyone as the dark brown, sticky material which constitutes the chief part of Liebig's Extract. We shall have something to learn about these extractives later on, but it may be stated here that the exact chemical nature of the more tasty is to a large extent unknown, that they have no direct nutritive value, but are of importance as being the chief cause of the characteristic taste of meat, and that, therefore, when they are removed, as they are, for example, on prolonged boiling, the meat becomes flavourless and insipid. Further, it would appear that the ***characteristic flavours of the different kinds of meat*** are due to minute differences in the amount and kind of the extractives present. The age of the animal and the way in which it is fed are of great importance in this connection. The flesh of full-grown animals is richer in extractives and has a fuller flavour than the flesh of those which are immature, which explains why we eat lamb with mint sauce and add spices to veal. The influence of feeding, on the other hand, is well illustrated by all forms of game. The flesh of wild rabbits, which eat aromatic herbs, especially thyme, has a much finer flavour than that of rabbits which are fed by hand, and a slice of wild duck is generally admitted to be a more tasty morsel than a piece of the bird reared in a farmyard. Everyone knows, too, how " fishy " sea-birds taste, how superior hill mutton is to its turnip-fed substitute, and how in grouse or capercailzie one can detect, as it were, an echo of the aroma of the heather or pinewoods amongst which these birds live.

The chemical composition of meat varies considerably, depending as it does on the particular "cut" examined, on the breed of the animal, and on the degree to which it has been fattened. It must be noted, also, that by no means the whole of ordinary butcher's meat consists of edible matter, a large part being made up of bone, gristle, tendon, and other inedible portions. In an average piece of meat these ***waste matters*** may be reckoned at 17 per cent. of the whole,[1] and the ***proportions of the constituents*** in the lean edible part are about as follows.[2]

Water	75	per	cent.
Intra-cellular protein	16·1	,,	,,
Extra-cellular (collagen, etc.)	2·4	,,	,,
Fat	3·0	,,	,,
Mineral elements	0·7	,,	,,
Extractives	0·8	,,	,,

Other analyses represent the proportions of the chemical substances present thus:

100 Parts of Lean Beef without Visible Fat (Bischoff and Voit)

Water	75·90
Protein (intra-cellular)	18·36
Gelatin (extra-cellular)	1·64
Fat	0·90
Mineral elements	1·30
Extractives	1·90

The *effects of fattening* are shown in the following table, in which the composition of lean, medium, and very fat beef is stated in round numbers:

	Water.	Nitrogenous matter.[3]	Fat.	Mineral elements.
Lean	76·5	21	1·5	1
Medium	73	20·5	5·5	1
Very fat	53	17	29	1

The chief points to note in this table are: (1) The large amount of water which meat contains. About three-quarters of its total

[1] *The Nutritive Values of War-time Foods.* Medical Research Council (1945).

[2] Bate-Smith. (1942), *op. cit.*

[3] "Nitrogenous matter" is the figure obtained by multiplying the amount of nitrogen in 100 parts by 6·25; i.e. it is assumed that it is all protein. In reality only 85 per cent. of the total nitrogen arises from protein and the remaining 15 per cent. comes from extractives. The factor for converting extractive nitrogen to extractives is 3·12.

weight is made up of water, or, stated otherwise, 1 lb. of meat contains ¾ lb. water and ¼ lb. of nutriment. It has been already pointed out that the flesh of young animals is relatively richest in water. (2) The relation between water and fat. The more there is of the latter present, the less there is of the former; in other words, when fat is deposited in a muscle, it replaces water, and not protein, and so the gain in nutritive value is an absolute one, and is not attained at the expense of a loss of nitrogenous constituents. The above analyses refer especially to beef; the composition of the other commoner sorts of meat and some varieties of game may be graphically represented as in Fig. 23.

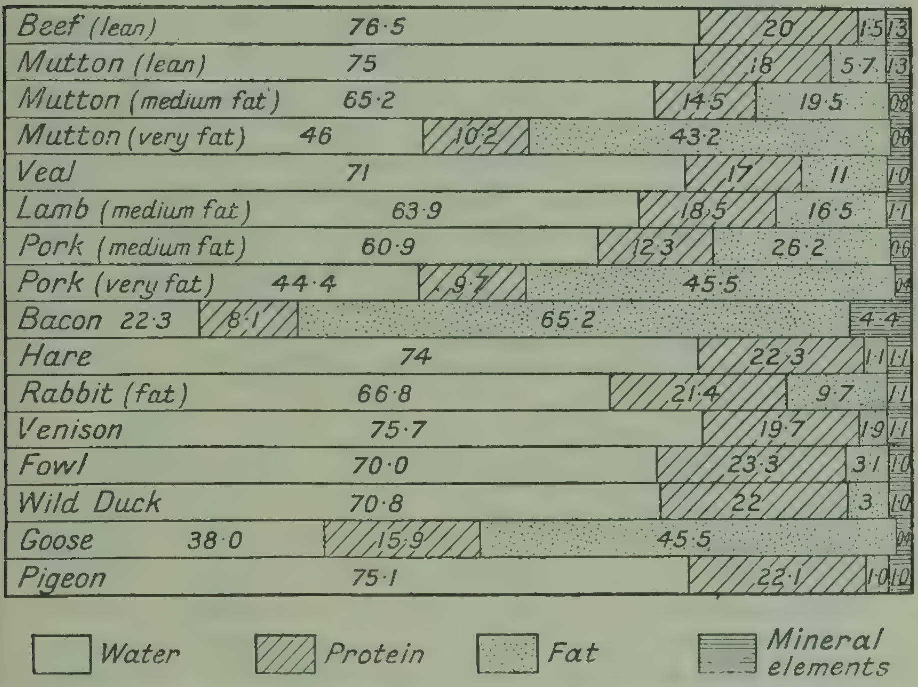

Fig. 23.—Composition of some Commoner Varieties of Meat and Game.

It must be clearly realized that these results are merely approximate, and may vary considerably in different cases. Thus, in very young calves the amount of water in the flesh may be 80 instead of only 71 per cent. The relative proportions of gelatin and other protein also fluctuate considerably. The flesh of young animals has more gelatin in proportion to protein than that of older animals hence the value of veal in making soups. Red and white meats differ but little in their content of extractives, including purines.[1]

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[1] McCance and Shipp. (1933), "The Chemistry of Flesh Foods and their losses on Cooking." *Med. Res. Council Special Report Series.* No. 187.

Changes Effected by Cooking. We have already stated that the general effect of cooking on the structure of meat is (1) to loosen the fibres by converting the connective tissue which holds them together into gelatin, and (2) to remove some of the fat. The exact proportion lost depends on its melting-point, the fierceness of the heat, the time of exposure to heat, etc.

The chief effect of cooking on the chemical composition of meat is to diminish the amount of water which it contains. It occurs even when the meat is boiled. This is important, for it entails a very considerable increase in the nutritive value of cooked, as compared with raw, meat, a result which is the very reverse of that which follows the cooking of vegetables. In consequence of this ***loss of water,*** an ordinary plateful of cooked meat, weighing 4 oz., may be regarded as equivalent to 5 oz. of raw meat. Another effect of cooking on the chemical composition of meat is the removal of part of the extractives. This is most marked when boiling is the method employed, but it also occurs to a considerable extent even in roasting. Some of the salts are also dissolved out by boiling, and reference has already been made to the fact that cooking removes some fat as well.

The following table is compiled from analyses by McCance and Shipp.[1]

PERCENTAGES OF PROTEIN AND FAT IN COOKED MEAT

Meat.	Protein.	Fat.
Bacon, fried streaky rashers	24·0	46·0
Beef, corned	22·3	15·0
,, roast	26·8	12·3
Beefsteak, grilled	25·2	21·6
Chicken, boiled	26·2	10·3
,, roast	29·6	7·3
Duck, roast	22·8	23·6
Goose, roast	28·0	22·4
Grouse, roast	30·1	5·3
Guinea-fowl, roast	32·5	8·2
Ham, lean, boiled	23·1	13·4
Hare, roast	31·2	7·0
Mutton, roast leg	25·0	20·4
Partridge, roast	35·2	7·2
Pheasant, roast	30·8	9·3
Pigeon, roast	26·8	13·2
Pork, roast leg	24·6	23·2
Rabbit, stewed	26·6	7·7
Turkey, roast	30·2	7·7
Veal, roast fillet	30·5	11·5
Venison, roast haunch	35·5	6·4

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[1] *op. cit.* See also Hanna. (1933–4), *Journ. Amer. Diet. Ass.*, 9, 188.

DIGESTIBILITY AND ABSORPTION OF MEAT

All solid foods are digested in the stomach in a *physical* sense; that is to say, they are pulped, in which condition alone they are able to pass on into the intestine. But meat is a food which is chemically digested in the stomach; its protein is changed to metaprotein and albumose. Now, it may be laid down as a rule that the greater the extent to which the chemical digestion of a food goes on in the stomach, the easier does its mechanical digestion prove. Hence, although meat makes considerable demands on the gastric juice, it does not throw any great strain on the mechanical resources of the stomach, and for that reason it must be regarded as among the more easily digested of the solid foods.

The first change which takes place during the ***digestion of meat*** is that the fibres swell up and become softened; their colour then changes to a greyish-yellow; they fall apart, and the mass becomes pulpy. Last of all, the individual fibres split up either into longitudinal threads or transversely into discs. It will be evident that the ease with which these changes can occur must depend on many conditions. The harder and denser the connective tissue which holds together the fibres, the less readily will they separate, and the greater the amount of fat between the fibres the less readily can the gastric juice act upon the latter, hence the indigestibility of tough and fat meats. The longer and thicker the individual fibres, the more slowly are they split up; hence the improvement in the digestibility of tough meat which results from breaking up the fibres by pounding the meat across its cut ends. The ***influence of cooking*** also is of great importance.

In general it has been held that raw meat digests more easily than lightly cooked meat and that overcooked meat is difficult of digestion. By "lightly cooked" is meant a condition in which the meat is firm and not flaccid. So when its internal temperature reaches about 60–63° C. (140–145° F.) the meat becomes firm, but is still red. Well-done meat has reached an internal temperature of 70°–80° C. (158°–176° F.).[1] On the other hand Uffelmann,[2] in experiments on a boy with gastric fistula, and Clifford,[3] *in vitro*, maintain that raw meat is the most indigestible form. In view of the difficulty of chewing raw meat and of its antiferments and the probability of the psychological inhibition of gastric juice when raw meat is eaten, we should expect it to be less well digested than cooked meat. Individual idiosyncrasies may account for the conflict of views in feeding patients. Such idosyncrasies should be respected when feeding the sick.

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[1] BAKER. (1942), *Chem. and In.*, 458.

[2] *Deut. Arch. f. Klin. Med.*, (1877), **20**, 535.

[3] *Bioch. Journ.* (1930). **24**, 1728.

The Relative Digestibility of the different kinds of Meat. Few exact data are available with regard to this. There is a general impression that ***mutton*** is more easily digested than beef, which some have attributed to the finer fibres and looser connective tissue of the former. ***Veal*** is believed to be somewhat difficult of digestion, though this is denied on the Continent of Europe. The difficulty of digesting veal is somewhat surprising, for the connective tissue, though abundant, is very easily changed into gelatin. It is believed by some that the explanation is to be found in the ease with which the fibres of veal elude the teeth on mastication ; the rather insipid taste of veal may also be a contributive cause, for such foods do not tend to excite a free flow of gastric juice. ***Pork,*** too, is accounted indigestible though the rate of passage of pork from the stomach does not bear out that suggestion ! On the other hand, ***bacon*** can often be eaten with impunity by persons to whom pork is intolerable. If we accept the rate of passage of foods through the stomach as a measure of their digestibility we find that lamb among the meats is a little more digestible than beef, and that pork is less digestible than beef. Pork chops, fried ham and bacon remain still longer in the stomach. The secretion of acid by the stomach is inversely proportional to the time of passage of the food through the stomach—at any rate with meats.[1]

The breast of ***chicken and game*** is amongst the most digestible forms of meat, but the leg muscles are often very tough. Very fat poultry, e.g. duck and goose, should be avoided by the dyspeptic, as the fat of such birds renders the flesh indigestible.

The ***absorption of meat*** is high. It has been shown that only about 5 per cent. of the organic matter in meat fails to enter the blood, and that, as the result of this, meat is a food which leaves a very small residue in the intestine. This gives it a special value in some cases of intestinal disease.

NUTRITIVE VALUE AND ECONOMY OF MEAT

The principal nutritive constituent of meat is protein and it is as a compact and easily-digested source of this that meat is chiefly of value. ***Meat protein*** is characterized by the rapidity with which it can be digested and absorbed into the body ; its absorption coefficient is remarkably high ; and it has a high biological value. It is, moreover, a " quick fuel " with a high specific dynamic action. This gives it an advantage in cold weather, but because of these "heating" qualities its use should be restricted in summer.

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[1] HAWK, REHFUSS, and BERGEIM. (1926), *Amer. Journ. Med. Sci.*, **171**, 359.

It has been held that meat proteins (or possibly the extractives of meat) produce a stimulating effect on the cells and on the body generally, and the feeling of well-being which follows a meat meal has been put down to this cause. Meat is also supposed to arouse animal passion and to excite savages not accustomed to it to a nervous condition amounting almost to intoxication.

All this must surely be exaggerated, for it is not borne out by observations on the diet of native races. Whereas the Masai [1] may be warlike on their diet consisting mainly of milk, meat and blood, the Eskimos on a diet of meat, fish, game and eggs are one of the most peaceful of peoples and from all accounts not libidinous.

Meat is one of the few articles of diet on which life can be supported alone for an almost indefinite time, even by inhabitants of temperate climates. It is stated that Stefánsson, the Arctic explorer, during one of his expeditions lived solely on meat for nine months, and that during that time he reached his maximum weight, was in excellent health and never suffered from constipation.[2]

These observations have been followed up by a series of laboratory experiments in the Russell Sage Institute upon Stefánsson and one of his assistants in Arctic exploration. Both lived on a diet of animal protein, mainly meat, for a year and there was nothing to differentiate them during that year either from other normal people or from their state before and after the experiment except a mild ketonuria [3] which, however, was accompanied by none of the usual subjective symptoms. There was much less flatulence as judged by X-ray photographs than when on a mixed diet and the stools were not offensive.

A meat diet entails an extremely high intake of protein, less of fat and still less of carbohydrate. Stefánsson found, both in his Arctic voyages and in his experimental period of meat diet, that fat was essential and lean meat alone not tolerated.

There is evidence that most of the ills attributed to a high meat diet—nephritis, high blood pressure, deposition of urates in the joints, lowered alkali reserve, increased putrefaction in the colon and constipation—are non-existent. Man has survived possibly a million years of such diet. Moreover, there are to-day hardy races, both in polar and equatorial regions, whose diet is mainly meat. There is no evidence that the Eskimos suffer more from nephritis, hyperpiesia and arthritis than Europeans or Americans.

[1] (1931), *Med. Res. Council Special Report.* No. 155,

[2] Clarence Lieb. (1926), *Journ. Amer. Med. Assoc.*, 88, 25.

[3] McClellan and Du Bois. (1930), *Journ. Biol. Chem.*, 87, 651.

It is true that the Masai [1] suffer from arthritis, but a medical officer from Kenya, in a private communication, gave it as his opinion that it is probably gonococcal in origin and not dietetic. We conclude that these supposed ills are unsubstantial bogeys.

None the less, meat as a sole source of food is impossible mainly on account of its cost. Besides, it would take anything from 3 to 5 lb. of meat daily to supply the requisite number of Calories, and meat, as a food, is rather bulky.

The relative nutritive value of different sorts of meat depends chiefly on the amount of fat they contain. Fat, as we have seen, replaces part of the water, and not the protein, of the leaner meats, and thus the fat meats are better sources of fuel than the latter, while not inferior to them in building material. Kean's employment of different meats according to the part he had to play that night—pork for tyrants, beef for murderers, and mutton for lovers—has, as yet, no strictly scientific backing.

The Economic Aspect of Meat as a Food. From an economic point of view ***meat is a dear food.*** This holds good whether one regards meat merely as a yielder of energy or as a source of building material.

The costliness of it, however, can be considerably diminished by selecting the cheaper " cuts," which are equal in nutritive value to the dearer kinds, though inferior in tenderness and flavour. The question of waste from bone, etc., must also be considered. Thus, in the case of mutton and pork, the leg contains relatively less bone than the shoulder, and in beef there is a much larger proportion of bone in the shin than in the round, and of these the least bony parts will be the most economical from a nutritive point of view. Much, too, can be done to diminish the cost by the use of the cheap ***chilled meats*** which are now imported. These are equal in nutritive value to fresh meat, and are only slightly inferior to the latter in keeping qualities. They are not much drier than ordinary meats, as is often stated, for chemical analysis shows that the proportion of water is only 10 per cent. less than that of fresh meat, while their digestibility is precisely the same. From an economic point of view, also, it must be regretted that there exists a prejudice against the use of ***horse-flesh*** as a substitute for ordinary meat. It is well flavoured—indeed, a Chateaubriand steak is said by connoisseurs to be best when made of horseflesh—and any toughness can be overcome by suitable cooking.

It should be remembered that all small animals, such as rabbits, are necessarily expensive forms of meat both on account of their active metabolism, which implies that the greater part of the food they eat is lost in the form of heat, and also because of the relatively large bulk of their viscera. It is therefore impossible to hope that they can ever be a cheap form of animal food for the poorer classes.

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[1] ORR and GILKS. (1931), *Med. Res. Council Special Report.* No. 155.

Offal. There remain to be dealt with parts of animals, other than the flesh, which are sometimes used as food, and which are usually classed together under the unsavoury title of **offal.** These comprise such articles as the kidneys, liver, sweetbreads, blood, heart, lungs, and other internal organs, and together they make up about one-third of the total weight of the carcase. The importance of some of these in diet cannot be overrated.

The general composition of these articles is shown in the following tables :

PERCENTAGE COMPOSITION OF OFFAL (RAW)

	Water.	Nitrogenous matter.[1]	Fat.	Carbohydrates.	Mineral elements
Blood	80·8	18·1	0·2	—	0·85
Brain	80·6	8·8	9·3	—	1·1
Heart (ox)	62·6	16·0	20·4	—	1·0
„ (sheep)	69·5	17·0	12·6	—	0·9
Kidney (ox)	76·7	16·9	4·8	0·4	1·2
„ (sheep)	78·7	16·8	3·2	—	1·3
Liver (ox)	71·2	20·7	4·5	1·5	1·6
„ (sheep)	61·2	23·1	9·0	5·0	1·7
Lung (ox)	79·7	16·1	3·2	—	1·0
„ (sheep)	75·9	20·2	2·8	—	1·2
Sweetbreads	70·9	16·8	12·1	—	1·6
Tongue (ox) fresh	63·8	17·1	18·1	—	1·0
„ smoked and salted	35·7	24·3	31·6	—	8·5
Tripe	74·6	16·4	8·5	—	0·5

COMPOSITION OF OFFAL (COOKED) (AFTER MCCANCE AND SHIPP)

	Protein.	Fat.	Carbohydrates.	Calcium.	Iron.	Phosphorus.	Calories per oz.
				mg.	mg.	mg.	
Brain, calf, boiled	12·0	5·8	0	16·0	2·0	355	29
Heart, sheep, roast	25·0	14·7	0	9·5	8·1	389	68
Kidney, ox, stewed	25·7	5·8	0	20·8	7·1	392	45
Liver, calf, fried after rolling in flour	29·0	14·5	2·4	8·8	21·7	576	74
Sweetbread, sheep, stewed	22·7	9·1	—	14·3	1·6	596	51
Tongue, sheep, fresh, stewed	18·0	24·0	—	11·1	3·4	196	84
Tripe, dressed, stewed	18·0	3·0	—	127·0	1·6	132	29

[1] N × 6·25.

It will be observed that, from the chemical point of view, they are substances of considerable nutritive value, and as their price is also for the most part low, as compared with that of ordinary meat, they must be regarded as important sources of protein in the diet. Moreover, they have remarkable properties in supplying protective factors in the diet, such as vitamins, iron, etc. Liver has massive quantities of vitamin A and the B complex and available iron ; the rest are very useful for vitamin B_1.

The ***liver and kidneys*** resemble one another in being compact, solid organs, containing but little connective tissue. This physical property renders them somewhat difficult of digestion, unless they have either been minced before cooking (as the liver is, for instance, in making a haggis or a faggot), or are rather carefully chewed. Chemically, both consist chiefly of protein along with a small amount of fat. The proteins which they contain are different from those of ordinary meat: for example, there is much nucleo-protein, which yields nuclein on digestion. Now, nuclein is an important source of uric acid, and for that reason gouty persons are recommended to avoid the dietetic use of the articles under consideration.

The ***heart*** resembles ordinary meat very closely as far as chemical composition is concerned, but differs from it in being of a denser structure, and therefore less digestible. For healthy persons, however, it is an excellent and economical food, and might with advantage be made larger use of than it is at present.

It seems natural to suppose that ***blood*** must be a very valuable food. "The blood is the life," and it would seem as if blood must represent in itself the essence of strength and energy. But it is not so ; and the misconception proceeds from a neglect of the fact that blood is not *in itself* the food of the tissues, but is merely the vehicle by means of which nourishment is carried from the intestines to the places where it is wanted in the body. One might as well expect a spoon to be of nutritive value because it conveys food from the plate to the mouth. Two French experimenters, Payen and Magendie, found that blood when administered to dogs, even in the liberal measure of 2 lb. daily, did not suffice to maintain the life of the animals for more than a month. This is due in part to the fact that blood is a dilute fluid, for, of every 100 parts of it, from 78 to 82 consist of water. Blood, in fact, from a chemical point of view, is not so much thicker than water after all. In the solids there is plenty of protein, but the other nutritive constituents of food—fat and carbohydrates—are only represented in quite small amount. In addition to this, the red colouring matter (hæmoglobin) which makes up the larger part of the protein is a substance which is very far from being completely absorbed. There are, thus, no chemical considerations which can outweigh the natural repugnance which most persons feel to the eating of blood; and though it may be used without harm, if also without much benefit, in the form of black-puddings and suchlike, there is no reason to advocate its habitual consumption, much less its employment in the feeding of the sick; and this is true also of the use of blood as a source of iron.

The ***lungs,*** from the fact that the air which they contain enables them to float in water, are popularly spoken of as the "lights." They are sometimes eaten, but cannot be regarded as a really good form of food. Their chemical composition furnishes the reason. The lungs contain large amounts of elastic material which, though protein in nature, is only imperfectly capable of digestion.

Under the term ***sweetbread*** butchers include at least two distinct organs. The "throat sweetbread" is known to anatomists as the thymus gland; the "stomach sweetbread" as the pancreas. The thymus of the calf is the one most frequently met with in the market. Both glands are cellular organs, held together by a loose and delicate connective tissue. From the nature of the latter they are easily digested in the stomach, and rank amongst the most digestible of animal foods, 9 oz. of sweetbread being completely disposed of by a healthy stomach in 2¾ hours, while a similar weight of beefsteak demands at least 4½ hours for its complete digestion.[1] These organs contain much nucleo-protein, and for that reason, as has already been pointed out in the case of the liver and kidney, sweetbreads may prove harmful in some cases of gout.

Tripe is the name applied to the stomach and intestines of the ox after being cleaned and boiled. It contains a large amount of connective tissue, readily changed into gelatin on boiling, and so rendering the fibres easily digested. It contains fat in small amount, but not diffused through the muscular part. Its rate of passage through the stomach is slower than that of beef,[2] but in the intestine it has been found to be as completely absorbed.[3] Unfortunately, the absence of extractives causes tripe to be rather deficient in flavour, but otherwise it must be regarded as a valuable and easily-digested food.

The ***brain*** of animals is only occasionally eaten as food. Brain consists largely of a fatty material containing cholesterol and lecithin, the latter being comparatively rich in phosphorus. In the

[1] PENZOLDT. (1893), *Deut. Archiv. f. Klin. Med.*, **51**, 535.

[2] HAWK *et alii.* (1919), *Amer. Journ. Physiol.*, **49**, 174.

[3] SOLOMIN. (1896), *Arch. f. Hygiene*, **27**, 176.

stomach, owing to its soft consistency, brain is more rapidly digested than any other animal food, but, unfortunately, it is very imperfectly absorbed, 43 per cent. of it reappearing in the fæces (*vide infra*). In spite, therefore, of its easy digestion, it cannot be regarded as a valuable food for invalids, nor is it in any sense specially apt to "make brains." "Some fancy," says an ancient writer,[1] "that Rabbits' Brains weaken the Memory, because this animal cannot for a moment after retain in mind the Foils laid for her and that she had just escaped; but this conjecture, being grounded upon a weak Foundation, I shall not stop here and go about to confute it." The idea that brain can in any way contribute to the nourishment of brain is grounded on an equally "weak foundation."

The comparative absorption of some of the articles of which we have been speaking, as found by experiment, is given below.

Voit [2] states that:

100 parts of dry	liver	yield	5	parts of dry	fæces.
,, ,,	lung	,,	8	,,	,,
,, ,,	thymus	,,	7	,,	,,
,, ,,	brain	,,	43	,,	,,

Emil Bergeat [3] found the loss of nitrogen in the dog to be:

In meat	2·1 per cent.
In thymus	3·2 ,,
In liver	3·3 ,,
In lung	4·2 ,,
In brain	13·9 ,,

Potted Meats. The average composition of some potted meats is represented by the following table (from König):

	Water.	Nitrogenous matter.	N-free Extractives.	Fat.	Mineral elements.	Salt.
Foie gras . .	46·04	14·59	2·67	33·59	3·11	0·22
Potted beef . .	32·81	17·17	3·36	44·63	2·03	—
,, ham . .	20·57	16·88	—	50·88	6·78	5·72
,, tongue .	35·52	18·46	0·46	32·85	6·71	5·98

These substances require no special description.

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[1] Lemery, (1745).

[2] *Zeit. f. Biologie*, (1889), **25**, 232.

[3] *ibid.*, (1888), **24**, 120.

Sausages are preparations of very uncertain composition. It has been remarked of them with some truth that they are like life; for you never know what is in them till you have been through them. Sausages which are sold to be eaten cold have been cooked; those which are meant to be cooked are made of uncooked meat to which bread, seasoning, and herbs have been added. The following analyses by Allen[1] represent the composition of some typical kinds:

COMPOSITION OF SAUSAGES

Variety.	Water.	Fat.	Protein.	Gristle, etc.	Starch.	Mineral elements.
German	46·54	17·87	16·38	1·13	15·00	4·47
Mutton	55·58	30·51	1·89	3·11	3·90	2·50
Polony	45·57	32·66	17·26	0·54	2·30	2·80
Pork	54·99	21·04	12·28	0·67	1·05	3·52
,, "Cambridge" .	51·54	29·72	9·45	0·72	2·20	3·47

McCance and Widdowson[2] give the following figures for pork sausages:

Protein.	Fat.	Carbohydrate.	Mineral Matter.	Energy value per oz.
8·8	28·8	9·8	2·2	98

Of war-time sausages, the less said the better, but the Medical Research Council gives the following composition:

	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Vitamin B_1	Calories per oz.
				mg.	mg.	I.U.	
Sausages, beef .	11·5	13·0	13·0	30	2·0	50	61
,, pork .	10·5	18·0	13·0	30	1·0	57	73

Analyses of other more recondite sausages and of tinned meats for Army use are given by Atwater and Bryant[3] and by Plimmer[4] respectively.

[1] *Commercial Organic Analysis*, Second Edition, 4, 280.

[2] McCance and Widdowson. (1942), *The Chemical Composition of Foods.* H.M. Stationery Office.

[3] Atwater and Bryant. (1906), *Chemical Composition of American Food Materials.* U.S. Dept. of Agriculture, Washington.

[4] Plimmer, R. H. A. (1921), *Analyses and Energy Value of Foods.* H.M. Stationery Office.

As sources of protein and of Calories, they are certainly not more economical than ordinary meat and their carbohydrate content must be taken into account when feeding a diabetic. They contain more vitamin B_1 than would be expected from the fact that sulphur dioxide is used to preserve them.

The use of bones as food will be dealt with later.

Preserved Meat. As was said earlier in this book, one of the problems presented to man by Nature is to make food keep from a time of glut to a time of scarcity. The industrialization of large numbers of the human race has made that problem still more urgent, and methods have been sought to preserve food produced in plenty in agricultural areas till it reaches man in the town. Particularly is this true of meat, which very rapidly becomes unfit for consumption when exposed to bacterial and other infection. Consequently many different methods have been evolved for making meat keep. Of these the important are salting or pickling, with or without smoking, canning, drying and dehydration.

Pickling. This has been practised for many hundreds of years, and is applied chiefly to products of the pig. The flesh and blood of animals is practically sterile and a skilled butcher can eviscerate an animal without the flesh becoming contaminated. The sources of infection are the knife with which the pig is stuck, and with the ox, the hide. Consequently the knife must be sterile and the skin or hide cleansed before slaughter or sterilized (as in the case of the pig) after killing. The muscle itself has such a hydrogen ion concentration ($P_H = 5{\cdot}5$) that putrefying organisms cannot grow. So if the exterior can be salted to prevent growth of bacteria, the whole can remain sterile for long periods of time.

Salt, mixed with potassium or sodium nitrite, is rubbed into the exterior surfaces of the jointed carcase, and penetrating to some distance renders the outside surfaces incapable of supporting bacterial life, though moulds do, with careless storage, manage to grow. In commerce, the salt mixture in solution is often pumped into the deeper strata. The nitrate, being reduced to nitrite, fixes the colour of the hæmoglobin by converting the hæmoglobin to nitroso hæmoglobin. After pickling, the sides are wiped with sterile cloths, and then baled and shipped immediately. Home curing proceeds by salting the joints—ham, gammon and sides—without pumping the pickling mixture into the deeper parts.

Subsequent smoking still further inhibits invasion by microbes and the development of rancidity. Pickled and smoked bacon and ham will keep under ordinary household conditions for at least a year.

Apart from economic considerations—for the pig is the best converter of agricultural products into first-class protein and fat apart from the milch cow—there are dietetic reasons for encouraging the bacon industry. Ham and bacon are more digestible than pork, and retain, in their cured condition, most of the vitamin B_1 which is the hallmark of the flesh of the pig. Whereas ordinary meat contains only some 50 I.U. of B_1 per 100 grammes, pork and cured pork may contain four to six times as much.

Salting is applied to coarser joints of beef (brisket and silverside) but rather to render them more appetizing than to preserve them. The attempts to cure mutton by salting and smoking, practised in the early days of the war of 1939–45, proved a failure.

Analyses of bacon and ham are here given :[1]

	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Phosphorus.	Calories per oz.
				mg.	mg.	mg.	
Bacon, raw, Danish "Wiltshire" . .	14·0	37·4	0	13·5	1·3	122	115
Bacon, raw, English "Wiltshire" . .	12·5	49·3	0	13·5	0·9	94	144
Bacon, back, fried .	24·6	53·4	0	11·5	2·8	229	169
,, streaky, ,, .	24·0	46·0	0	52·3	3·2	238	149
Ham, raw. . . .	15·0	49·0	0	14·2	1·2	104	146
,, boiled (lean and fat) . . .	16·3	39·6	0	12·7	2·5	192	123

Canning is a method of preserving meats from decomposition which has reached enormous dimensions in this century. Not only does it make meat available long after the animals were slaughtered (up to 100 years !) but it enables armies, polar expeditions and construction camps of all sorts to be fed with meat protein and fats, far from a base of supply of fresh meat, and preserves foodstuffs, used in the manufacture of meat extracts, which would otherwise be wasted (Corned beef.) There is a prejudice against canned meats due to conservatism and gastronomy and there have been, in the past, accidents of food poisoning traceable to careless processing, but with advance of technique these have been largely obviated. There are to-day more cases of food poisoning from "fresh" meat than from canned meat. It should be emphasized that the canners have discovered by experience that none but the best quality meat, canned under conditions of great cleanliness, have long "life" or marketable qualities. Processing consists in submitting meat enclosed in tinned and laquered containers to a temperature of

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[1] McCance and Widdowson. (1942), *op. cit.*

125° C. long enough for the heat to penetrate thoroughly to the centre of the container and sterilize any adventitious microbic life. Though such sterilization destroys the small amounts of vitamin B_1 and C contained in the meat, the proteins and fats are but little affected except that they are cooked. Canned meats are then a good and convenient source of protein and energy as the analyses show.

	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Phosphorus.	Vitamin A	Vitamin B_1	Calories per oz.
				mg.	mg.	mg.	I.U.	I.U.	
Corned beef	22·3	15·0	0	12·8	9·8	119	—	—	66 [1]
,, ,,	25·0	16·0	0	10·0	11·0	—	0	0	69 [2]
,, pork	20·0	23·0	0	10·0	2·0	—	0	450	81 [2]
Luncheon meat .	15·0	21·0	0	—	—	as above	—	—	71 [2]
Pork sausage meat	9·0	43·0	1·0	—	—	as above	—	—	121 [2]
Tongue .	19·0	20·0	0	10·0	3·0	—	0	280	73 [2]

Drying has been used from time immemorial by North and South American Indians for preserving meat (pemmican and charque) but it to-day finds little use, except in polar expeditions. If all the water is removed from lean beef the composition of the product would be about as follows:

Protein	86·8 per cent.
Extractives	7·8 ,, ,,
Mineral elements	5·4 ,, ,,

Beef powders made from dried meat form the basis of the diet of polar explorers. Its value is enhanced by the addition of 40 to 50 per cent. of fat—the amount varying with the inclinations of the head of the party—and when mixed with boiling water it forms the "Hoosh" familiar to readers of the accounts of exploration. Bulk for bulk dried powdered beef mixed with fat is about the most concentrated food known.

Dehydration. During the war of 1939–45 considerable advance has been made in the drying of meat which has been previously partly cooked and minced. The meat, with the cooking liquors distributed over it, is dried either at 60° C. in air or at 70°–80° C. under slight vacuum. The flavour and nutritive value, so far as protein and fat are concerned, are fully preserved and the loss of vitamin B_1 is comparable with that of normal home-cooked meat. Meat so dried when packed in airtight containers with the air replaced by an inert gas can be expected to keep in good condition for years.[1] This method was used during the war to save transport, but what its commercial future will be in years to come is somewhat speculative.

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[1] McCance and Widdowson. (1942), *op. cit.*

[2] Medical Research Council (1945).

Soups, Beef extracts, Beef juices and Beef tea. In previous editions of this book considerable space was devoted to these substances but it has been considered unnecessary to repeat what has been said in the past. There is but little to be added to the summary given in the 9th Edition:

1. The extractives of meat are incapable either of building up tissues or of supplying the body with energy, and are therefore not foods.
2. They do not act as cardiac stimulants.
3. They may possibly help to remove fatigue, either by acting on the nervous system or on the muscles directly, but this action cannot yet be regarded as proved.
4. On the other hand, there is no doubt that they powerfully aid digestion by calling out a flow of gastric juice, whilst their pleasant flavour enables them to rouse the appetite. They are therefore useful additions to other foods, especially where the appetite and digestion are feeble, and may also be taken with advantage at the beginning of a meal, as in the form of soups.
5. If taken in large amount they excite diarrhœa.
6. Ordinary beef-extracts (e.g. Liebig's) possess no properties other than those of the extractives of meat. The amount of protein which they contain is negligible.
7. Preparations, such as Bovril and Oxo, to which meat powder has been added, may theoretically be regarded as foods, but contain far too little protein to admit of their ever being able to contribute appreciably to nutrition.
8. Beef-juices differ from beef-extracts in containing the proteins of meat in a coagulable form. None of them, however, can be taken in sufficiently large quantity to supply much protein to the body.
9. Natural (home-made) raw-beef juice contains about 5 per cent. of coagulable protein, which is as much as many of the patent preparations, whilst its comparative poverty in extractives and salts enables it to be consumed in fairly large amounts. It is also very much cheaper than the patent preparations.
10. Ordinary beef-tea, even when carefully prepared, does not contain more than 2 per cent. of nutritive matters. It may aid appetite and digestion, but is of very little value as a food. Its

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[1] Bate-Smith, Sharp and Cruickshank. (1944), *Proc. Nut. Soc.*, **1**, 118.

nutritive qualities, however, can be enhanced by adding to it the finely-powdered fibre of the meat (" whole beef-tea "). It is doubtful if the salts of beef-tea are of any real use.

We add that the defence of the use of soups must be along the lines that they are a pleasant opening to a large meal, especially in cold weather, they are gastric secretogogues, they may contain the " extrinsic factor " for hæmatopoiesis, and form a good vehicle for vegetables, milk and cheese. Whatever growth-promoting factor beef-tea contains is due to gelatin (q.v.). The hold which these preparations have on the public is due to a cleverly conducted and intensive advertising campaign.

ANALYSIS OF SOUPS[1]

	Protein	Fat.	Carbo-hydrate.	Calcium.	Iron.	Phos-phorus.	Calories per oz.
				mg.	mg.	mg.	
Bone and vegetable broth, home-made .	3·7	4·6	1·1	16·9	0·28	9·9	18
Ditto, commercial. .	4·4	—	0·3	10·2	0·28	7·0	—
Hospital soups (mean of samples) . . .	2·0	1·3	4·3	33·8	1·39	40·0	10

COMPOSITION OF THICK SOUPS (KÖNIG)

	Nitrogenous matter.	Fat.	Carbo-hydrate.	Cellulose.	Mineral elements.	Calories per fluid ounce.
Pea soup . . .	3·38	0·93	5·60	0·70	1·13	15
Potato ,, . .	1·37	1·53	4·87	0·26	0·99	11

COMPOSITION OF EXTRACTS OF MEAT[2]

	Meat Fibrin.	Albumoses and Peptones.	Gelatin.	Non-nitrogenous material.	Creatine and Creatinine.	Mineral elements.
No. 1	1·3	0·5	0·2	trace	8·5	21·0
No. 2	1·9	1·0	0·3	,,	8·1	23·6
No. 3	nil	0·7	trace	,,	4·7	20·0
No. 4	,,	0·9	,,	,,	4·6	20·7
No. 5	5·3	0·4	0·5	,,	5·5	20·3
No. 6	6·0	22·4	0·5	,,	6·1	18·2
No. 7	8·6	13·3	0·4	10·0	6·3	28·5
No. 8	0·6	17·5	8·7	7·0	1·4	15·9

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[1] McCANCE and WIDDOWSON. *op. cit.*

[2] COX. (1936), *Chem. and Ind.*, **55**, **69**.

Since a level teaspoon holds about 3·5 c.c. it can be seen how little nutriment is obtained in a cup of meat extract made as the manufacturers direct.

COMPOSITION OF COMMERCIAL BEEF JUICES

	Coagulable Protein.	Non-coagulable Protein.	Non-nitrogenous Material.	Extractives.	Mineral Elements.	Alcohol.
A . .	0·53	9·12	—	11·16	10·84	—
B . .	5·28	10·17	—	16·55	8·85	—
C. . .	3·71	9·29	—	8·10	14·20	—
D . .	8·3		—	9·54	7·51	—
E . .	11·25		4·25	—	—	11·35
F . .	33·38		6·75	13·44	13·27	—
G . .	21·0		—	6·0	6·5	—
H . .	4·40–7·37		59·56	0·55	1·24	—

As meat is a good source of nicotinic acid and a moderate source of riboflavine, it is to be expected that meat extracts should contain great amounts of these vitamins. This is so. Meat extracts per 100 grammes contain 37·5 to 102·5 milligrammes of nicotinic acid and 2·34 milligrammes riboflavine.[1] Doubtless they will be well advertised on that score.

Extracts prepared from yeast have for many years been used as substitutes for ordinary meat-extracts, and are largely used for flavouring the canned stews put up by the canning firms. A good example of these is the preparation known as ***Marmite.***[2]

COMPOSITION OF MARMITE

Water	26·84 per cent.
Nitrogenous extractives . .	34·67 ,,
Peptides and amino-acids . .	10·50 ,,
Mineral matter	26·95 ,,

Such preparations resemble beef-extracts so closely in their general characters that they are used to dilute genuine meat-extracts.[3] The chief chemical difference between beef-extract and an extract of yeast appears to consist in the presence of creatine and creatinine in the former, and their absence in the latter; yeast extract also contains relatively more of the base adenine.[4] Whether these slight

[1] BOOTH and BARTON-WRIGHT. (1944), *Lancet,* 565.

[2] Analysis supplied by the makers.

[3] For the method of distinguishing yeast-extract from genuine meat-extract, see papers by A. SEARL. (1903), *Pharmaceutical Journal,* 4th series, **17**, 516, 704.

[4] GAMGEE. (1908), *Brit. Med. Journ.,* **2**, 449.

chemical differences involve a different action in the body is still undetermined, but there is no reason to believe that yeast-extract is in any way unwholesome, although it may, perhaps, not have quite the same stimulating effect on gastric secretion that genuine meat-extracts have. It is a good source of the vitamin B complex and of the extrinsic factor necessary for hæmatopoiesis.

Gelatin. The chemical basis of jellies is gelatin. Gelatin is derived from collagen, which is the chief constituent of connective tissues, and is converted into gelatin by boiling. Most forms of connective tissue can be made to yield gelatin by suitable treatment. Glue is a crude form of the substance obtained from hide-clippings, and ordinary commercial gelatin is simply a purified form derived from the same source. The connective tissues of young animals are especially rich in gelatin-yielding material. Veal, for example, contains 4 to 5 per cent. of connective tissue, and is therefore a favourite basis for the making of strong soups. Calves' feet (free from bone) yield 25 per cent. of gelatin on boiling and 11·3 per cent. of fat, and have long been known as abundant yielders of a pure jelly. The purest form of all, however, is ***isinglass,*** a substance obtained from the swim-bladder of fish, especially of the sturgeon. Chemically it is less rich than ordinary gelatin, as is shown by the following comparative analyses :

	Ordinary Gelatin.	Isinglass.
Water	13·6	19·0
Gelatin	84·2	77·4
Fat	0·1	1·6
Carbohydrate . . .	—	—
Ash	2·1	2·0

The chief physical peculiarity of gelatin is its capability of dissolving in boiling water, and setting into a jelly on cooling. It is remarkable how weak a solution is capable of doing this. Even when as little as 1 per cent. is present the solution sets. The ordinary strength of which jellies are made is 1 oz. of gelatin to the pint, which is equivalent to a 5 per cent. solution, and from this one can realize how little gelatin there really is in ordinary jellies. Hutchison found that 6 oz. (a large helping) of ordinary calf's-foot jelly contains 1⅔ oz. of solid matter, of which less than ½ oz. is gelatin, the remainder being chiefly sugar.

The ***digestion of gelatin*** *in vitro* or *in vivo* is a very easy process ; indeed, in this respect it is hardly surpassed by any other food. Uffelmann found that, in a boy with a gastric fistula, complete peptonization took place within an hour, but he does not state how much jelly was administered.

Gelatin has the advantage of fixing a good deal of acid in the process of digestion, and is thus of service in cases of hypersecretion of acid in the stomach. It seems also to belong to the " peptogenic " substances—i.e. those bodies which favour an abundant flow of gastric juice.

Nutritive Value of Gelatin. Highly purified gelatin is devoid of cystine and tryptophane, and nearly devoid of phenylalamine and tyrosine and has little methionine. It is therefore incapable by itself of building human tissue.[1] But it contains arginine and lysine which are amino-acids of the highest value. Therefore mixed with other protein, e.g. even the second-class proteins of bread, it is very valuable. None the less, it must be remembered that not more than about 1 oz. of gelatin can be conveniently taken in the day—the amount in 1 pint of jelly. One can realize from this that the usefulness of gelatin in dietetics is of limited range. As a pleasant addition to the diet of convalescence, however, jellies are of service, but their nutritive value depends mainly on the sugar which they contain, and not on the gelatin. Their value in acid dyspepsia has already been mentioned.

The *cost of gelatin* depends entirely on the source from which it is derived, and for ordinary purposes commercial gelatin is the most economical. It has been calculated that it costs sixteen times as much to prepare jelly from calves' feet as to use commercial gelatin for the purpose (Thudichum). Isinglass is also a costly source, a pint of jelly made of commercial gelatin costing about 6*d.*, whereas if isinglass be used it will cost about 1*s.* 3*d.*, and it does not even seem to be altogether true that the latter goes farther and sets better. The same is true of soups, for it is cheaper to add 7 or 10 grammes (¼ to ⅓ oz.) of gelatin to ordinary stock if a strong soup is wanted than to get the gelatin from boiling veal. Bones are a cheap source of it only in so far as they cannot be used for any other purpose. The composition of bones is as follows :

Water	5 to 50 per cent.
Gelatin-producing material .	15 to 50 ,, ,,
Fat	½ to 20 ,, ,,
Mineral elements . . .	20 to 70 ,, ,,

When boiled in the usual way they yield from 1½ to 7 per cent. of their weight, mainly as fat. When broken up and treated in a Papin's digester the yield is much greater. None the less it is cheaper to use commercial gelatin than to buy bones specially to produce it. McCance, Sheldon and Widdowson[1] make a point of the worthlessness of bone and vegetable broth for the purpose for which the bones are included, i.e. to supply calcium for growing children. Whereas commercial broth supplies 10 milligrammes calcium per 100 grammes and laboratory made broth 16·9 milligrammes, cow's milk supplies 119, and its protein is mainly gelatin against the first-class protein of cow's milk.

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[1] See MURLIN. (1907), *Amer. Journ. of Physiol.*, **19**, 285; ROBISON, (1923), *Biochem. Journ.*, **16**, **111**.

Gelatin is a cheap addition to poor diets in so far as it can be obtained from many materials which would otherwise be wasted, and ordinary jellies can only be regarded as dear foods, for, say, two shillings spent on the "calf's-foot jelly" of the shops yields at most 470 Calories and no first-class building material at all.

[1] McCance, Sheldon and Widdowson. (1934), *Arch. Dis. Childh.*, **9**, 251.

CHAPTER XV

FOODS TAKEN FOR MINERAL ELEMENTS AND FOR VITAMINS A AND C

In this chapter it is proposed to deal with fruit and fruit products, leafy and other vegetables and fruits used as vegetables. With the usual carelessness of popular dietetics the custom is to lump fruits and vegetables together as the main source of "minerals" and vitamins. It is necessary thus early to protest against this and say that calcium and phosphorus are far better obtained from cheese, fish and milk than from fruits and vegetables, iron from eggs and liver, while butter, eggs, fat fish, liver and milk contain much vitamin A, and liver and nuts are valuable for vitamin C. We have already called attention to these points and noted that potatoes, dealt with under energy foods, are still, unfortunately, the main source of vitamin C in the British diet, for so many people refuse to eat cabbage. The contribution of vitamins of the B class which fruit and vegetables make to the diet is distinctly small. As they make but little addition to our sources of energy and protein,[1] but are often extraordinarily useful for vitamins A and C they are grouped together in this chapter. Fruits often are, but by no means always, a good source of vitamin C, and yellow fruits of vitamin A as well; green leafy vegetables produce vitamins A and C and yellow vegetables vitamin A. The green vegetables, with the exception of the spinach family, have a useful amount of iron and some of the cabbage family make a small contribution to our intake of calcium.

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[1] The proteins of leafy vegetables are first-class proteins, but there is so little obtainable from a consumable amount. Methods of concentration of this protein are still in their infancy and may be neglected. SLADE, BRANSCOMBE and McGOWAN, (1945), *Chem. and Ind.*, 117; LUGG and WELLER, (1944), *Biochem. Journ.*, **38**, 408, have found methionine, tyrosine and tryptophane well represented in grass and lucerne proteins.

FRUITS

The fruit is not of direct benefit to the plant. It is intended as a bait to attract animals, and so insure the liberation or transportation of the seed. Hence æsthetic qualities predominate in fruit rather than the strictly nutritive, and we eat them more for the sake of their sweetness and flavour than for the actual nourishment which they afford.

The *general composition of fresh fruit* is approximately:

COMPOSITION OF FRESH FRUIT

Water	85 to 90 per cent.
Protein	0·5 ,,
Fat	0·5 ,,
Carbohydrates	5½ to 10½ ,,
Cellulose	2½ ,,
Mineral elements	0·5 ,,

The composition of individual members of the group is shown in the table on page 437, and a study of the graphic representation of some typical fruits will illustrate it (Figs. 24, 25 and 26). It will be observed that the only nutritive constituents of any importance in fruit are the *carbohydrates*. These consist almost entirely of sugars, only very few ripe fruits containing any starch. The chief sugars are fructose and glucose and in most fruits these are present in nearly equal proportions. Apples and pears, however, contain much more fructose than glucose, whilst in most stone fruits, on the other hand, glucose predominates. A few fruits (e.g. cherries, grapes and figs) contain no sucrose, whilst in a few others, such as apricots and peaches, it makes up the greater part of the total sugar present.

The remainder of the carbohydrates is made up of non-metabolizable substances such as cellulose, hemicellulose, pectin, etc. In the course of ripening, some of them are converted into the corresponding sugar—*pentose*, the nutritive value of which must be regarded as very doubtful.[1] When subjected to boiling, the gums of many fruits yield a jelly, the production of which is familiar in the process of making preserves.

The amount of *cellulose* varies greatly in different fruits. It is always lessened by the process of cultivation—witness the difference between a crab apple and a Newton pippin—and it diminishes also, by a sort of natural digestion, during the ripening of the fruit.

The *mineral constituents* of fruits are of little importance.

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[1] See McCANCE. (1929), *Med. Res. Council Rep.* **135, Part 2,**

They consist mainly of potassium united with various vegetable acids, such as tartaric, citric, and malic. These have an agreeable acid flavour and reaction, but when burnt by the body are converted into the corresponding carbonate, and so render the blood more alkaline and the urine less acid. A grapefruit weighing ¾ lb. contains about 20 grammes of sugar and from 0·13–0·4 grammes of acid citrates.[1] The ability of the human body to oxidize citric acid is so great that at least 48 grammes can be dealt with in a day. Hence the drinking of quantities of orange-juice tends to make the

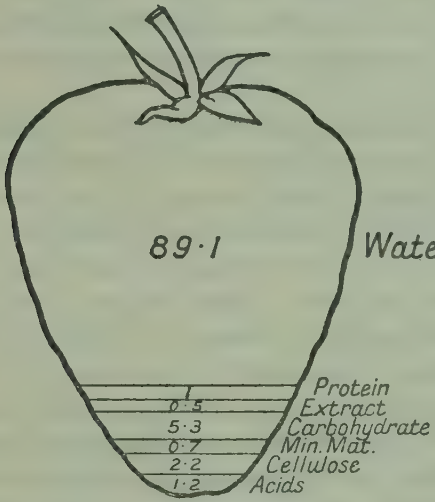

Fig. 24.—Percentage Composition of a Strawberry.

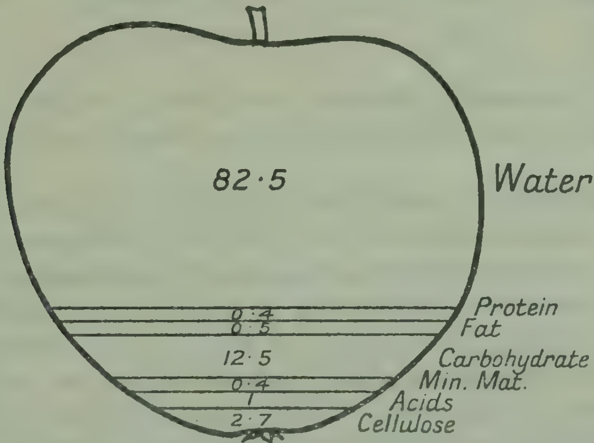

Fig. 25.—Percentage Composition of an Apple.

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[1] *La Presse Médicale.* (1926), 34, 1613.

urine alkaline.[1] As the fruit ripens, these vegetable acids diminish, and it is to this fact, coupled with an increase in the amount of sugar present and a decrease or insolubilization of tannic acid, that the sweetness of ripe as compared with unripe fruit is due.

Fresh fruits, with the exception of grapes, plums and some apples, are also important vehicles of the ***anti-scorbutic vitamin.*** (See pp. 172 and 173.)

The ***odour and flavour of fruits*** are due to the presence of very small quantities of ethereal bodies which sometimes elude chemical investigation. In many cases, however, we have been able to obtain (from coal-tar, too, of all sources) artificial products which have to the uncritical palate the same flavour as many fruits. These products, alas, form the basis of the different fruit flavourings and essences sold in the shops. Although of no nutritive value, the flavouring substances contained in fruits are by no means to be despised as stimulants to the appetite and aids to digestion.

Cooking renders most fruits more digestible by softening their cellulose, and it also, as we have seen, converts the gums into a gelatinous form. But these changes are not brought about without a good deal of loss. The loss affects all the ingredients of the fruit. The following instances show figures for the carbohydrates : [2]

Apples, raw . .	11·7 per cent.	Peaches, raw . .	9·5 per cent.
,, once boiled	7·3 ,,	,, once boiled	1·8 ,,
,, twice ,,	6·1 ,,	Pears, once boiled .	6·6 ,,
Pears, raw .	10·1 ,,	,, twice ,,	5·9 ,,

Where, as is usually the case, the fruit is cooked by stewing and the juice eaten along with it, this effect of cooking is of no moment.

The ***digestibility of fruit*** in the stomach and intestine is dependent largely on the nature of the fruit and its degree of ripeness. Five and a third ounces of raw ripe apple (one large or two small apples) require about 3 hours and 10 minutes to pass through the stomach. On the other hand, if the fruit is unripe and the amount of cellulose consequently greater, digestion may be much more prolonged. The excess of acids present in unripe fruit causes it to be irritating to the intestine, and a frequent originator of diarrhœa and colic. If, however, the cellulose and acids are contained in more moderate quantity, as in ripe fruit, the gentle stimulation which they exert on the intestinal wall may be very

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[1] BLATHERWICK and LONG. (1932), *Journ. Biol. Chem.*, **53**, 103.

[2] From analyses by KRAUS. (1898), *Zeit. f. Diät. und Physik. Therap.*, **1**, 69.

COMPOSITION OF FRESH FRUITS

	Grammes per 100 grammes.				Mg. per 100 grammes.								Acid-base, Balance per 100 grammes.	Vitamins. I.U. per 100 grammes.			
	Protein.	Available Carbohydrate.	Unavailable Carbohydrate.	Calories per 100 grammes	Na.	K.	Ca.	Mg.	Fe.	Cu.	P.	Cl.		A.	B₁.	C.	Remarks.
													c.c. $\frac{N}{10}$ Alkali.				
Apples, Empire, eating	0·3	12·2	1·7	51	2·7	116	3·6	5·0	0·29	0·14	6·8	1·0	30	—	—	} 28–80	Poor for C.
,, eating, English	0·3	11·7	2·2	49	2·0	120	3·5	4·3	0·29	0·07	8·5	2·0	26	—	40		
,, cooking, English	0·3	9·6	2·4	41	2·1	123	3·6	2·9	0·29	0·09	16·2	4·6	23	—	—	320	(Bramley's seedlings.)
Apricots	0·6	6·7	2·1	30	1·0	320	17·2	12·3	0·37	0·12	21·3	1·0	84	3000	—	16	
Bananas	1·1	19·2	3·4	83	1·2	348	6·8	41·9	0·41	0·16	28·1	78·5	79	250–340	30	146–300	Moderate for C.
Blackberries . . .	1·3	6·4	7·3	32	3·7	208	63·3	29·5	0·85	0·12	23·8	22·1	84	—	10	—	
Cherries, eating . .	0·6	11·9	1·5	51	2·8	275	15·9	9·6	0·38	0·07	16·8	1·0	73	—	—	62	
Currants, black . .	0·9	6·6	8·7	31	2·7	372	60·3	17·1	1·27	0·14	43·2	14·8	88	300	10	2720	The highest source of C. with the exception of hips, haws, and paprika.
Currants, red . . .	1·1	4·4	8·2	23	2·3	275	35·8	12·8	1·22	0·12	29·5	14·0	59	—	—	1000	Very good for C.
Damsons	0·5	9·6	4·1	41	2·0	261	21·2	9·9	0·37	0·07	14·8	1·0	74	—	—	—	
Gooseberries, green .	1·1	3·4	3·2	18	1·9	210	28·3	7·1	0·32	0·13	33·9	6·5	41	—	—	552	Good for C.
,, ripe . .	0·6	9·2	3·5	40	1·2	170	18·5	8·6	0·58	0·15	19·0	10·7	37	—	—	—	
Grapes (white) . . .	0·6	16·1	0·4	68	1·6	250	19·1	6·6	0·34	0·10	21·9	1·0	60	25	—	20	Poor for C.
Grapefruit	0·6	5·3	0·6	24	1·4	234	17·1	10·4	0·26	0·06	15·6	1·3	64	—	40	520	Good for C.
Greengages	0·8	11·8	2·6	52	1·4	305	16·8	7·7	0·37	0·08	22·6	1·0	77	—	—	10–138	Poor for C.
Lemon juice . . .	0·3	1·6	0·0	8	1·5	142	8·4	6·6	0·14	0·13	10·3	2·6	38	—	—	520	44 per cent. of a lemon is juice.
Loganberries . . .	1·1	3·4	6·2	18	2·5	257	35·1	25·0	1·37	0·14	24·3	15·8	74	—	—	408	Good for C.
Melons (Cant.) . . .	1·0	5·3	1·0	26	13·5	319	19·1	20·1	0·81	0·04	30·4	43·5	75	—	10	300	Moderate for C.
Orange juice . . .	0·6	9·4	0·0	41	1·7	179	11·5	11·5	0·30	0·05	21·7	1·2	45	300	—	440	57 per cent. of a 9 oz. orange is juice. 41 per cent. of a 6 oz. orange is juice.
Peaches	0·6	9·1	1·4	40	2·7	259	4·8	7·9	0·38	0·05	18·5	1·0	61	760	—	20–220	
Pears eating . . .	0·3	10·8	2·1	43	2·3	129	8·0	9·3	0·19	0·20	9·9	1·0	34	80	30	20	Poor for C.
Pineapple	0·5	11·6	1·2	50	1·6	247	12·2	16·9	0·42	0·08	7·8	28·5	70	166	2·5	208	Moderate for C.
Plums, dessert . . .	0·6	9·6	2·1	42	1·7	188	11·0	7·2	0·36	0·10	16·3	1·0	48	115	0	20	Poor for C.
Raspberries. . . .	0·9	5·6	7·4	27	2·5	224	40·7	21·6	1·21	0·21	28·7	22·3	61	—	25	610	Good for C.
Rhubarb	0·6	1·0	2·6	6	2·2	425	102·8	13·6	0·40	0·13	21·0	87·0	—	—	—	—	Ca probably unavailable.
Strawberries . . .	0·6	6·2	2·2	28	1·5	161	22·0	11·7	0·71	0·13	23·0	17·5	35	—	—	920	Very good for C.
Tangerines	0·9	8·0	1·9	36	2·2	155	41·5	11·2	0·27	0·09	16·7	2·4	53	690	40	200	Moderately good for C.
Tomatoes	0·9	2·8	1·5	15	2·8	288	13·3	11·0	0·43	0·10	21·3	51·0	56	14,160	40	258	Frequently higher than this.

useful. Hence it is that stewed fruit is so serviceable an addition to the diet for the atonic colon.

There have been few experiments made to test the degree to which fruit is absorbed by the human intestine, but one may expect that at least 95 per cent. of the available carbohydrate, if not more, will be absorbed, and that is practically all that matters.

From a nutritive point of view fruits may be artificially divided into the two groups of ***flavour-fruits*** and ***food-fruits.*** In the first group are included all fruits which contain less than 20 per cent. of solid material ; in the second, all fruits or fruit preparations which have more than 20 per cent.

The only claim of the members of the first group to be regarded as foods is that they contain a small amount of sugar in a pleasant but rather bulky form, and some of them contain vitamin C and most contain vitamin P. A rough generalization is that citrus and summer fruits only, with the exception of cherries, are significant sources of vitamin C, whereas the autumn fruits, though often almost devoid of vitamin C, are useful for vitamin P. They are chiefly eaten for the sake of their agreeable flavour. Their richness in water makes them more adapted to the requirements of the inhabitants of warm countries than for use in northerly latitudes, and it is found if they are freely represented in the diet less water need be consumed.

Grapes stand intermediate between the two groups, for their juice contains an amount of sugar which varies from 10 per cent. in the poorer up to 30 per cent. in the richer varieties. In the so-called ***grape-cure,*** from 1 to 8 lb. of grapes are taken daily in divided quantities, and between meals. If the rest of the diet is sufficient, the patient may gain weight on this regimen, while the grape-juice, owing mainly to the organic acids which it contains, acts as a mild laxative and diuretic, and at the same time diminishes slightly the acidity of the urine. Grapes contain practically no vitamins, so far as is known.

There are many unfermented grape-juices preserved by pasteurization on the market. They contain about 25 per cent. of grape-sugar, and are a useful food-beverage, especially in fevers. To-day, in this country, there is an " orange cure," which consists of combining rest or graduated exercise, fasting from all foods except orange juice, with some psychotherapeutic treatment. Some of the successes claimed for this treatment, we suspect, are due to making good a deficiency of vitamin C.

The ***food fruits,*** on the other hand, are by no means to be despised as a source of calories. Of this group the ***banana*** is a good example. It is the fruit of a tropical plant (*musa sapientum*) which for some reason or other has forgotten to make seeds but continues to make the pulp in which they should be embedded. Bananas are largely grown for export to this country in the West Indies, the mainland of Central America, the Canary Islands, and the Cameroons.

A large banana weighs on the average 143 grammes or 5 oz., and its pulp 90 grammes or $3\frac{1}{6}$ oz. The relation of the edible portion to the fruit as purchased is 62·5 per cent. Small fruits may weigh as little as 2 oz., their pulp not much over 1 oz., and the percentage of edible material is 58·5 per cent. The size depends on the position the fruit holds in the bunch and on the time at which it is cut. Fruit on the American market, because of its proximity to the West Indies, is cut later than the fruit destined for the English market. It has therefore time to grow larger.

As will be seen from the tables, the chief value of this fruit in dietetics is its high content of carbohydrate and its considerable amount of vitamin C. Figures for the vitamin C of bananas as sold in England are as high as 15 milligrammes ascorbic acid (300 I.U.) per 100 grammes.[1] Their contents of vitamin B_1 (14 to 30 I.U.), and of vitamin A (250–340 I.U.) are not negligible. Weight for weight, the banana gives at least as many calories as potatoes, but whereas the carbohydrate of potato is starch that of the fully ripe banana is sucrose and invert sugars. When the banana is green its carbohydrates are mainly starch and if eaten green it should be cooked. As the fruit ripens the starch is converted to sucrose, fructose, and glucose, and when fully ripe, i.e. when the yellow skin is covered with brown flecks, there is almost no starch present. This is the condition in which the connoisseur eats the banana.

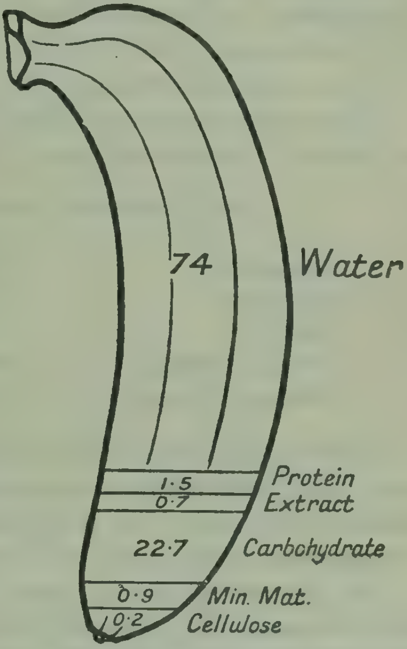

FIG. 26.—PERCENTAGE COMPOSITION OF A BANANA.

Apart from its convenience and cheapness, which makes it the fruit of choice for the packet lunch, the meal at mid-morning break, picnic, etc., the banana has achieved a considerable reputation in pediatrics and medical dietetics. Enterprising American and Canadian pediatricians give it as the first solid food a baby gets and as early as 3 months. British pediatricians give it at 6 months. The babies take readily to it and thrive on it. It is used in the United States to help a child put on weight. In this country, in Germany and the United States and Canada, the banana is used with success in feeding babies suffering from diarrhœa and cœliac disease.[1] It must be very ripe when used for this purpose. During the war of 1939–45 the Ministry of Food allowed the importation of amounts of dried bananas to be used in treating infants with diarrhœa. It is also an excellent food in the diet for sprue and for a spastic colon in the adult.

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[1] CHAPPELL's figures are 11·5–11·9. 1940 (*Journ. Hygiene*, **40**, 699); L. J. HARRIS's for ripe Jamaica bananas, 11·9–15·2; and OLLIVER's, 6–8 (private communications).

The unripe banana is dried and used to produce ***banana meal*** or ***flour.*** A sample of such a flour had the following composition :

COMPARISON OF BANANA AND WHEAT FLOUR

	Banana Flour.	Wheat Flour.
Moisture . . .	13·0 per cent.	13·8 per cent.
Protein . . .	4·0 ,,	7·9 ,,
Fat	0·5 ,,	1·4 ,,
Carbohydrates . .	80·0 ,,	76·4 ,,
Mineral elements .	2·5 ,,	0·5 ,,

We have placed alongside it the composition of a good wheat flour, compared with which the banana meal is rich in carbohydrates and mineral elements, but poor in protein. If rice had been used for comparison, banana meal would be about equal to it.

An advantage of the banana is the cheapness with which it can be produced. A given area devoted to its cultivation will yield a larger food return than if planted with potatoes. The bread-fruit, the sugar cane and the chestnut are said, however, to exceed the banana in their yield per acre.

Dried Fruits. Surpassing even the banana in nutritive value are the dried fruits, e.g. the currant, date, fig, raisin and sultana. The date is as much a staple article of diet to the Arab as rice is to the Hindu, but the carbohydrate of the date is almost solely sugar whereas that of rice is starch. Dried fruits have received much advertisement in the United States for their content of iron, though the tables hardly bear this out, but we call attention to the large amounts of calcium and iron in dried figs. Dried fruits, unlike fresh fruits, have a high Calorie value ranging from 50 per ounce (dried apricots) to 68 (dates). Advantage of this is taken by school caterers, rock climbers and " hikers." They must not be relied

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[1] PARSONS. (1932), *Am. J. Dis. Child.*, **43**, 1293.

Composition of Dried Fruits [1]

	Grammes per 100 grammes.		Calories per lb.	Milligrammes per 100 grammes.								Vitamins. I.U. per 100 grammes.		
	Protein.	Available Carbo-hydrate.		Na.	K.	Ca.	Mg.	Fe.	Cu.	P.	Cl.	A.	B_1.	C.
Currants .	1·7	63·1	1346	19·5	708	95·2	36·2	1·82	0·48	40·4	15·7	—	—	Probably nil
Dates . .	2·0	63·9	1369	4·8	754	67·9	58·5	1·61	0·21	63·8	290·0	600	30	,, ,,
Figs . .	3·6	52·9	1174	86·7	1015	284·0	92·3	4·17	0·24	91·5	166·0	—	9	,, ,,
Prunes .	2·4	40·3	871	12·2	864	37·7	26·7	2·90	0·16	83·0	2·5	—	66	,, ,,
Raisins .	1·1	64·4	1362	52·2	860	60·6	41·7	1·55	0·24	32·8	8·5	—	50	,, ,,
Sultanas .	1·7	64·7	1379	52·7	856	52·2	35·3	1·82	0·35	94·5	15·5	—	60	,, ,,

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[1] Analyses from McCance, Widdowson, and Shackleton. (1936), *Med. Res. Council Rep.* No. 213, and vitamins from Roscoe and Fixsen. (1937–8), *Nut. Abs. and Rev.*, 7, 823.

upon for vitamin C and so cannot take the place of fresh fruits in the dietary.

Canned fruits, once considered useful only for sugar and flavour, have been shown by a long series of experiments in this country by Olliver [1] to retain much of their original vitamin C. In fact they may contain more than fruit bought on the open market and stewed in the home. Such fruits as black currants, when canned, supply as much as 90 milligrammes of vitamin C per 100 grammes (3½ oz.) and form a very valuable source of that vitamin when, because of the season or the difficulty of importation, citrus fruits are unavailable. During the war of 1939–45 the Ministry of Food used the black currant purée (first manufactured on the initiative of Olliver) to provide infants and invalids with vitamin C. (Average content : 65 milligrammes per 100 grammes or 18 per oz). The content may be even higher than this, for allowance is made for deterioration between the time of packing and the time of consumption. Canned gooseberries (18 milligrammes per 100 grammes), loganberries (12), raspberries (12), and strawberries (25) are useful, though by no means as good as black currants, for vitamin C.

VEGETABLES

There is no logical classification of vegetables possible either from the botanical or the culinary standpoint. Man has shown enormous ingenuity in seizing upon, and diverting to his own use, the leaves, shoots, seeds and storage parts of plants, and what are classed as vegetables in normal speech may be fruits or seeds, with or without their pods, e.g. aubergines, cucumbers, marrows, tomatoes, French and runner beans and peas, and what is classed as a fruit, is really a stem, or rather a petiole (e.g. rhubarb). The following classification is offered, with apologies, for convenience merely.

Green and leafy vegetables : The cabbage family including broccoli, cauliflower, mustard and cress, seakale and watercress, and the spinach family.

Leguminous green vegetables.

Salad vegetables {Endive and lettuce (usually eaten green).
Celery, chicory, dandelion (eaten blanched).

Asparagus and globe artichokes.

Bulbs, roots and tubers : Artichokes (Jerusalem), beetroot, carrots, onions, parsnips, potatoes and salsify.

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[1] OLLIVER. (1936), *Chem. and Ind.*, **55**, 153 ; (1938), *Analyst*, **63**, 2 ; (1943), *Chem. and Ind.*, **62**, 146.

Seeds : cereals and pulses.

Fruits : aubergines, cucumbers, marrows, pumpkins, squash and tomatoes.

With the pulses and cereals we have dealt already, for their main function in diet is to provide Calories and protein. As a general dietetic rule pulses (and cereals) should not be used as a second vegetable, though dried peas and beans are in this country, and " noodles " in Germany.

Green and Leafy Vegetables. ***The Cabbage Family.*** This is an enormous tribe most of which—e.g. broccoli, sprouting broccoli, white and purple, brussels sprouts, cabbage, calabrese, cauliflower, kale of various types, kohl rabi and seakale, savoy, spring and winter cabbage, have been developed by gardeners, mainly Dutch, from the wild, and natural, brassica maritima. Mustard and radishes and watercress also belong to the same family, the cruciferæ. The swede and the turnip also were developed from brassica maritima, but are dealt with later.

The plant spreads its leaves out to absorb the energy from the sun's rays by means of its chlorophyll, which is invariably accompanied by carotene, the precursor of vitamin A. Iron is always found in the neighbourhood of the chloroplasts which contain the chlorophyll. Also to catalyse the active chemical changes in the leaf, when it combines carbon dioxide from the air with water, aided by the energy absorbed from the sun's rays, to form sugars and starches, it needs vitamin C, among other catalysts. So we expect to find in green leaves, vitamin A, vitamin C and iron. The greener the leaf usually the more vitamin A and iron. The outer green leaves of cabbage have more vitamin A, iron and, incidentally, calcium, than the pale inner ones, but these are by no means devoid of vitamin C. In fact where a vegetable is the nature of a growing shoot (sprouts, sprouting broccoli, and calabrese) vitamin C may be expected in large amounts.

Of course, like other vegetables, the cabbage tribe have large amounts of potassium and magnesium which are, however, usually found in any diet in excess of man's needs.

The analyses on page 444 are taken from the Medical Research Council's tables : *The Nutritive Values of War-time Foods.*

It will be seen at once how negligible these vegetables are for Calories, but what a useful source for vitamins A and C, how they contain significant amounts of iron, and, in the case of kale and watercress, of calcium. Little of the vitamin A, the iron or the calcium is lost in cooking [1] but there is a big diminution of vitamin C.

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[1] McCance, Widdowson and Shackleton. (1936), *Med. Res. Council Special Rep.* 213.

Food.	100 grammes contain							Calories per oz.
	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Vitamin A as Carotene.	Vitamin C.	
	g.	g.	g.	mg.	mg.	I.U.	mg.	
Brussels sprouts	4·4	0	4·0	27	1·2	400	100	7
Cabbage . .	1·5	0	5·0	65	1·0	900	70	5
Cauliflower. .	2·4	0	3·0	23 [1]	0·9	0	70	4
Kale . . .	3·9	0	4·5	200	2·5	4,000	130	7
Turnip tops .	2·5	0	3·5	[98]	[3·0]	10,000	100	5
Watercress. .	2·9	0	0·6	222	1·6	5,000	60	3

Olliver [2] considers that 100 grammes cooked cabbage contain but 16 milligrammes vitamin C whereas when raw, the figure was 70. Sprouts show a decrease from 100 milligrammes (raw) to 30 milligrammes cooked, and these are probably optimal figures.

The Spinach Family. These (summer spinach, winter spinach, seakale beet) are like the cabbage tribe in being sources of vitamins A and C, but are probably useless for calcium and iron because of the oxalates they contain. Again there is loss of vitamin C on cooking (65 milligrammes falls to 25 per 100 grammes), but probably none of vitamin A precursors. As with the cabbages their Calorie value is negligible (4 per oz.)

Leguminous Green Vegetables. These are broad, French and runner beans and green peas. Sometimes these are eaten pods and all (French and runner beans, sugar peas and young broad beans), and sometimes the seeds are shelled and eaten alone (flageolets, peas). Not only are such vegetables quite useful for vitamins A and C, but they afford more protein when eaten shelled than ordinary green vegetables. The following analyses illustrate these points.

Food.	100 grammes contain							Calories per oz.
	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Vitamin A as Carotene.	Vitamin C.	
	g.	g.	g.	mg.	mg.		mg.	
Beans, Broad .	7·2	0·5	9·5	30	1·1	—	30	27
„ French.	1·1	0	2·6	33	0·7	600	10	4
„ Runner	1·1	Trace	2·9	33	0·7	600	20	5
Peas, green .	5·8	0	9·5	15	1·9	500	30	18

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[1] Cauliflower, boiled. (McCance and Widdowson, *op. cit.*)

[2] Olliver. (1943), *Chem. and Ind.*, **62,** 146.

Leafy Salad Vegetables. Endive and lettuce are useful practically only for vitamin A; they contain disappointing amounts of vitamin C though, judging by American figures, there are varieties of lettuce with high vitamin C values.

Food.	100 grammes contain							Calories per oz.
	Protein.	Fat.	Carbo-hydrate.	Cal-cium.	Iron.	Vitamin A as Carotene.	Vitamin C.	
				mg.	mg.		mg.	
Endive . . .	1·8	0	0·9	44	2·8	—	20	2
Lettuce . . .	1·1	0	1·6	26	0·7	4,000	15[1]	3

Celery, chicory and dandelion, though green leafy vegetables, are eaten blanched. They are probably useless for vitamin A, and the vitamin C of celery is low (5 milligrammes per 100 grammes), and their value is mainly gastronomic.

Asparagus and Globe Artichokes. These luxury articles are not of much importance in dietetics, except that asparagus contains much vitamin C, 60 milligrammes per 100 grammes (cooked 30 milligrammes). They both are vehicles for melted butter.

Food.	100 grammes contain							Calories per oz.
	Protein.	Fat.	Carbo-hydrate.	Cal-cium.	Iron.	Vitamin A as Carotene.	Vitamin C.	
	g.	g.	g.	mg.	mg.	I.U.	m.g.	
Artichokes (Jerusalem)	1·6	Trace	3·2	30	0·4	?	?	5
Asparagus . . .	2·0	0	2·4	28	0·9	700	60	5
Beetroot . .	1·8	0	8·1	32	0·9	0	10	7[2]
,, cooked	1·8	0	9·9	30	0·7	0	5	13[2]
Carrots . .	0·7	0	4·9	48	0·6	10 to 20,000	10	6
Leeks . . .	2·5	0	3·9	51	1·3	700	20	4
Onions . . .	0·9	0	4·7	31	0·3	0	10	6
,, spring .	0·9	0	7·7	135	6·2	700	20	8
Parsnips . .	1·7	0	10·2	55	0·6	200	10	9
Radishes . .	1·0	0	2·5	44	1·9	0	30	2
Salsify (boiled)	1·9	Trace	2·8	60	1·23	?	?	5
Swede . . .	0·7	0	2·4	40	0·3	0	20	4
Turnip . . .	0·5	0	1·8	55	0·3	0	15	2

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[1] Other values are 16 (Olliver, *op. cit.*) and 1–17 (Chappell, *op. cit.*).

[2] Difference due to sampling.

Bulbs, Roots and Tubers. Plants often store sugars and starches in roots and underground stems, though sometimes, as in the onion family, in swollen modified leaves. This gives them an early start in spring—e.g. the potato. Man naturally raids these stores. As the storage organs are often underground, devoid of chlorophyll, and have low metabolic rates, we expect but little vitamin C in them, though, as a matter of fact, new potatoes, radishes, swedes and turnips are not to be despised for that vitamin.

Little comment is necessary on these tables except to call attention to the spring onion and the leek as sources of vitamin C and the carrot as a source of carotene. It must be remembered, however, that carotene is absorbed into the blood with difficulty, and it is recommended that one third of the values given above be taken for vitamin activity. Eaten raw, the carrot probably would yield even less—say one sixth of the figures.[1]

Fruits used as Vegetables. These came from the classes solanaceae (aubergines and tomatoes) and the cucurbitaceæ (cucumbers, marrows, pumpkins etc.). It cannot be said that any, except the tomato, is of great dietetic value, though pleasant in cuisine.

Food.	100 grammes contain							Calories per oz.
	Protein.	Fat.	Carbo-hydrate.	Cal-cium.	Iron.	Vitamin A as Carotene.	Vitamin C.	
	g.		g.	mg.	mg.	I.U.	mg.	
Cucumber . .	0·6	0	1·6	23	0·3	0	10	2·5
Marrow . .	0·5	0	3·0	[14]	[0·2]	30	5	4·1
Pumpkin . .	0·6	0	3·4	39	0·4	?	?	4·7
Tomato . .	0·9	0	2·5	13	0·4	3,000	25	3·9

In the above tables most of the figures given are for raw vegetables, and a large number of these are usually eaten cooked. The difference this makes to the calcium, iron and vitamin A contents of the vegetables is slight. In fact, vegetables cooked in hard water may have more calcium, and those prepared with steel knives and cooked in iron containers may have more iron, than the raw samples. The chief loss is in vitamin C. Consequently the consumption of raw vegetable salads, made from the cabbage family and decorated with the highly coloured beet, carrot and tomato has been advocated, with some considerable success, in canteens and institutions where the cooking and service methods for vegetables unfortunately destroy much of the vitamin C.

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[1] Hypercarotenæmia, easily mistaken for jaundice, sometimes results from eating large amounts of carrots. *Lancet*, (1944), **2**, 478.

Two substances which may be of value in supplying mineral elements are mentioned here. They are Irish or Carrageen moss and Iceland moss. The former is a dried seaweed sometimes used in the sickroom. It has much calcium (0·845 per cent.), iron (88 milligrammes per 100 grammes), manganese (7 milligrammes per 100 grammes) and phosphorus (205 milligrammes per 100 grammes).

Iceland moss is a lichen and not a moss or a seaweed. Its nutritive value is probably nil, unless perhaps, it supplies some mineral elements.

Canned Vegetables.[1] There has been an enormous increase in the production and consumption of these commodities. Convenience in preparation and ease of transport mainly determine this. In the best restaurants, for example, canned green peas are usually served, even in the height of the season. It will be seen from the tables that there is no dietetic reason against their use.

ANALYSIS OF CANNED VEGETABLES

Food.	100 grammes contain							Calories per oz.
	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Vitamin A as Carotene.	Vitamin C.	
	g.	g.	g.	mg.	mg.	I.U.	mg.	
Asparagus . .	1·5	0	1·3	28	0·6	700	30	3
Beans, broad .	5·2	0·5	7·5	40	0·8	420	15	15
„ runner	0·8	0	1·8	35	0·5	600	5	3
Beetroot . .	1·4	0	5·7	35	0·6	0	5	8
Brussels sprouts	3·4	0	1·3	30	0·7	400	35	6
Carrot . . .	0·5	0	1·6	30	0·2	20,000	5	2
Celery . . .	0·5	0	0·6	60	0·3	0	2	1
Parsnips . .	0·9	0	5·5	70	0·3	200	5	8
Peas (fresh) .	4·6	0	5·8	25	1·0	500	15	12
„ (processed)	7·2	0	16·2	45	1·7	170	0	26
Spinach . .	2·1	0	1·0	0	0	7000	25	4
Swedes . .	0·7	0	2·4	40	0·3	0	20	4
Turnips . .	0·5	0	1·8	55	0·3	0	15	2

Vegetarianism. As we have now considered the nature, composition and functions of the various foods in the normal diet, it would be well to take up at this point the vexed problem of vegetarianism versus a mixed diet. There have been throughout the last hundred years flourishing societies of vegetarians in this country, western Europe and the United States. Almost undoubtedly their main motive power has been a revulsion from the taking of animal life, with which the average person must feel some sympathy, though schools of psychoanalysis may suspect repressed motives.[1] Almost naturally this cult is found among the more " progressive " parts of our communities.

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[1] See OLLIVER, *op. cit.*

To be consistent, vegetarians should subsist on nothing but cereals, fruits, pulses and vegetables or their products. For example, they should prefer soya bean milk to cows' milk. But vegetarians allow themselves the latitude of taking in addition to plant products, cheese, eggs and milk, and by the term " vegetarian " is usually meant one who abstains from flesh foods, i.e. fish, meat and poultry.

In support of their doctrines they adduce arguments from prehistory and the ability of many of their adherents to live a healthy and even athletic life, on a milk, eggs, cheese and vegetable diet. Man, they say, descends from a vegetarian stock, the monkeys. So the eating of flesh foods is a perversion of our inheritance. But it is forgotten that man has passed through a stage in prehistory of some millions of years, in which he has lived mainly upon animal food and that there are several races, e.g. the Eskimos and the Masai, who have survived to this day on an almost wholly animal diet. Nor are these races remarkable for poor physique, bad health or incompetence to meet adverse circumstances. Anyone who studies the tenets of the vegetarians cannot but feel that they have not " thought their problem through " either as regards the taking of life [2] or as regards what is " natural " or " unnatural " in diet.

To us the problem must be wholly dietetic, and we can sum up the advantages and disadvantages of a consistent vegetarian diet, as follows :

Cereals are weak in protein, and those which contain it in reasonable amounts have only second-class proteins. They have usually very little fat and calcium and are devoid of vitamin C.

Fruits are very weak in protein and fat. Their calcium is low and their only advantage is that many of them have vitamin C and a few of them vitamin A.

Nuts are the only vegetarian foods with protein (2nd class), fat and vitamin C.

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[1] e.g. repressed desire for cannibalism. (Personal communication to one of us—V. H. M.—by a Freudian psycho-analyst.)

[2] e.g. the slaughter of birds in a cherry orchard, or of bullocks and cockerels in the production of milk and eggs.

Pulses, when cooked, as they must be for human consumption, are bulky foods for protein and are devoid of fat and vitamin C.

Vegetables are very poor in protein and fat (though leafy, potato and rice proteins are of good quality), but, as stated immediately above, are often useful for vitamins A and C.

It will be seen that a diet composed solely of the above is likely to be weak in protein, fat and calcium, though, of course, extensive use of olives, peanuts and other nuts will make up the deficit in fat. The great objections to such a diet, apart from these lacunæ, are its bulk and the low absorption of its constituents in the alimentary tract. If the bulk is small and the percentage of cellulose scanty, digestion and absorption may, however, be very complete. Voit,[1] in early work on the absorption of some animal and vegetable foods, showed that, whereas only some 4–4½ per cent. of white bread, macaroni, polished rice, meat and eggs escaped digestion and absorption, the waste with black bread, cabbage, potatoes and turnips was much higher (11 to 20 per cent.). Bulkiness is common to the majority of vegetable foods, except bread and nuts. This is due to the great amount of water they contain. Most vegetables contain 80–90 per cent. of water, many of them more water than milk, the most dilute of animal foods. Even pulses when cooked contain 70 per cent. of water, or as much as the leanest of raw meat.[2] The only way to keep the bulk of a vegetarian diet low is to make extensive use of bread and biscuits. (Porridge has 89 per cent. of water.) Even then, a vegetable diet has a much larger volume than a purely animal or a mixed diet. According to Voit (*op. cit.*), a purely vegetable diet has three times the bulk of an animal one.

The bulkiness of vegetable food interferes with its digestion in two ways. First it is difficult for the digestive juices to penetrate such a mass and convert it into absorbable constituents; secondly, the bulk stimulates the walls of the alimentary tract to peristalsis, the food materials are hurried along and there is less time allowed for absorption.

Further, the great obstacle to complete digestion and absorption of vegetable foods is the presence of cellulose which is very imperfectly attacked by the digestive apparatus of man and carnivorous animals. Herbivorous animals have special portions of their alimentary tracts developed to deal with cellulose—the rumen in animals which chew the cud and the enormous cæcum in the horse and rabbit. Part of this cellulose is converted by the action of bacteria in the large intestine into hydrogen and marsh gas. Wherefore a vegetarian diet is a very " windy " diet. The fæces on such a diet are three times the bulk of those on a mixed diet.[1] One further objection to a highly vegetarian diet is that the production of urine is much increased, so that its consumer may be forced to get up at night to pass water.[1]

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[1] VOIT. (1889), *Zeit. f. Biolog.*, **25**, **232**.

[2] Cooked lean meat contains much *less* water.

The result of such a diet is distension of the gut by bulk and gas, frequency of defæcation and micturition and low absorption of protein, fats and carbohydrates.

Much of this may be avoided by the addition of eggs, milk and cheese to the diet. In fact there is no objection to be found in lactovovegetarianism, the vegetarianism practised by most vegetarians. Such a diet, indeed, seems advantageous to the gouty person who does better on it than on one into which meat enters to any large extent. The objections, clinical and otherwise, to a meat diet for the normal person are largely imaginary. We may add that a person embarking on a lactovovegetarian diet needs a good knowledge of modern dietetics to keep his diet "balanced," and should not be one prone to flatulence. Vegetarianism, though often wrong-headed, dogmatic and unscientific, has been of great service in emphasizing the importance of fruits and vegetables in the diet.

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[1] Private communication by McCance and Widdowson concerning experiments made in 1939–40, published April 1946, *M.R.C. Special Report*, Series 254, on diets containing large amounts of wholemeal bread and vegetables. See also diet of the Channel Islands during the German occupation. *Lancet*, (1945), **2**, 569.

CHAPTER XVI

FOODS TAKEN MAINLY FOR FLAVOUR. CONDIMENTS

A discussion on flavour is, unfortunately, inescapable in a book on the nature of foods, for we know so little about it. For flavour determines appetite and good digestion waits upon appetite, as was shown in an earlier chapter. Much, if not all, of our " tastes " in food depend upon conditioned reflexes—the Eskimo, according to Stefánsson, has no appetite for salt with meat—but the dietitian has no time to train his victims to new conditioned reflexes and has to work within their ambit. Flavour then becomes of great importance.

True taste arises from stimulation of the end organs in the tongue, by sapid substances, whereas true flavour comes from the stimulation of the olfactory epithelium high in the nasal cavity. Flavours then are really odours. Very naturally tastes and flavours are confused, for it is difficult to appreciate the fact that a viand rolled on the tongue is really being smelt, that volatile substances escape from it when it is eaten and, passing up into the nasal cavity, affect the olfactory epithelium. Most persons, however, are aware that they lose their sense of smell when suffering from a heavy cold and that food loses most of what is termed flavour. An onion becomes indistinguishable from an apple.

There are but four tastes: sweet, acid, salt and bitter. The front of the tongue appreciates sweet and acid things. People who suck sweets keep them in the front of the mouth. Lemonade and wines are sipped. The back of the tongue is responsible for reaction to bitter tastes, wherefore beer is drunk, not sipped. Salt sensations arise from stimulus of all parts of the tongue. All other "tastes," fruity, spicy, flowery, aromatic, alliaceous, nauseating and burnt, are really flavours. It is they, mainly, which make food appetizing or the reverse, though true tastes add something.

It should be said at the outset that we cannot, as yet, reconstruct synthetically the natural flavours of foods and essential oils, for the substances which produce flavours are multitudinous and work in extraordinarily small amounts.[1] It is true that ethyl butyrate reminds one of pineapples, amylacetate of pears and benzaldahyde of almonds, and are used to imitate those foods in sweets and marzipan to the degradation of the palate of the public. The flavour of the pineapple is more than ethyl butyrate. The idea that the flavour of fruits and other foods can be matched absolutely synthetically is a dream of the organic chemists, and a bad dream at that. The importance of flavours in foodstuffs is receiving recognition among manufacturers of foods, and it is the custom, e.g. in the manufacture of dried eggs, to submit this product to a panel of tasters. Wine, tea and coffee tasters have been a commonplace in those trades for years. The sphere of the professional taster must be expanded as our food passes more and more through the hands of the manufacturers.

The characteristic flavour of olive oil depends on saturated and unsaturated hydrocarbons. They occur in amounts of but 70 parts per million. Arachis oil, which may oust olive oil as a salad dressing, has similar substances but only in the amount of 1·8 parts per million. Butter, in part, owes its flavour to diacetyl and acetyl methyl carbinol, developed by the microbes responsible for the aroma of butter. One part in forty million of diacetyl can be detected, but while a mixture of the two substances can give a buttery flavour to foods, it is lacking in the true flavour. Cheese, as stated in the section on that food, owes its characteristic flavour to a great number of different aliphatic acids among other things.

Apple oils contain acetaldehyde, amyl formate, acetate, caproate with a trace of geraniol, but a synthetic apple " oil " is not at all a satisfactory substitute for the real flavour. Similarly esters have been extracted from peaches, but proved highly unstable in the presence of air. The characteristic flavours of fruits such as raspberries, black currants and strawberries remain chemical mysteries.

The bouquet of wines and spirits is another mystery. There are various esters of aliphatic and aromatic acids and their alcohols are also both aliphatic and aromatic ; moreover there are diacetyl, acetylmethyl and phenylmethyl carbinols present, but none of the compounds, nor a mixture of them, resembles to any degree the characteristic bouquet. With tea and coffee the problem is still more complicated. Fifteen odourous constituents have been isolated from black tea, and over twenty from coffee. It is interesting that mercaptans are important ingredients in coffee aroma.

Enough has been said to show that it is extremely unlikely that flavours can be synthesized in the chemical laboratory which can approach closely the flavour of fresh foods. Further, as many of the odourous substances in foods are chemically unstable, it is obvious that cooking, processing, long contact with air, moisture, etc., are going to influence flavours, often for the worse. A corollary is that it is almost impossible to free a substance from objectionable flavour once it has developed it.

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[1] See WAYGOOD. (1943), *Chem. and Ind.*, **62**, 59.

It has been suggested that the passionate interest shown from the Middle Ages to the seventeenth or eighteenth century in spices and other condiments was largely due to the desire to mask the flavour of tainted meat.[1] To-day condiments are used to enhance or make attractive the flavours of food.

Allspice, or pimento, is the fruit of a West Indian and Central American evergreen myrtle which contains 4–7 per cent. fixed and 3–5 per cent. volatile oil. Pimento oil should contain considerable quantities (65–90 per cent.) of eugenol to which it owes its flavour.

Caraway. This is the seed of an umbelliferous plant, native in parts of Europe and Western Asia and cultivated in Holland, Russia and Scandinavia. It can be grown in Great Britain but is usually imported from India. It is used as a flavouring to cakes and its volatile oil is the characteristic flavouring material in Kümmel. The chief odourous substance is carvone, a liquid ketone derived from limonene.

Cassia is the bark of an Oriental member of the Lauraceæ, *cinnamomum Cassia*, and contains 1·5 to 4·3 per cent. of a volatile oil, the chief constituent of which is cinnamaldehyde. The chief sources of supply are Ceylon and China.

Cayenne pepper is the ground fruit of *capsicum frutescens*, of the nightshade, potato and tomato family, and paprika of *capsicum annuum*. The former comes from East and West Africa and Japan, while paprika is mainly of Hungarian cultivation. There may be as much as 12 per cent. fixed and 1 per cent. volatile oil. These peppers own their violent action to capsaicin (0·22 per cent. of the product).

Cinnamon is the bark of the young wood of *Cinnamomum zeylanicum*, or Ceylon cinnamon. The feature which distinguishes it from cassia is that its oil contains less cinnamaldehyde and more eugenol. It imparts " a peculiar, illusive flavour appealing to the epicure."[2]

Cloves are the dried flower buds of an evergreen tree belonging to the myrtaceæ, a native of the Moluccas, but now cultivated in

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[1] DRUMMOND and WILBRAHAM. (1939), *The Englishman's Food*, 34, 35.

[2] WINTON and WINTON. (1939), *Structure and Composition of Foods*, **4**, 271.

Zanzibar, Madagascar, India and the West Indies. In cloves there is no less than 6 per cent. fixed oil and 19 per cent. volatile oil and the chief ingredient of the latter is eugenol (cp. Allspice or pimento), which is the main flavouring agent.

Ginger is the rhizome of a reed-like plant, needing moisture and a tropical climate, grown in India, Siam and China and also in East Africa and Jamaica. In China the green rhizome is preserved in syrup or candied and exported to all parts of the world. It is also dried, bleached and exported as root ginger. It contains about 4 per cent. fixed oil and 2 per cent. volatile oil. The fixed oils contain pungent principles, mainly zingerone, to which ginger owes its sharp taste. The volatile oils to which ginger owes its fragrance are mainly terpenes.

Mustard is a flour made from the seeds of black mustard (*brassica nigra*) mixed with that from white mustard (*brassica alba*). On moistening, the black mustard flour contributes volatile mustard oil and the white an excess of a ferment, myrosin, which sets free allyl isothiocyanate from the volatile oil to which the burning sensation produced by mustard is due. The substance upon which the ferment acts is potassium myronate, a glucoside which also occurs in horse radish roots and in turnips. It has a bitter taste but no decided odour until hydrolysed by the ferment.

Mustard flour contains from 15 to 25 per cent. of fixed oil, 0·5 to 2 per cent. volatile oil, 35 to 45 per cent. of nitrogenous matter, 1·6 to 4·9 per cent. of carbohydrate and cellulose and 4 to 6 per cent. of mineral elements.

Nutmeg is the kernel of the small pear-like fruit of *Myristica fragrans* from the East Indies (Penang, Singapore, etc.) but it is also cultivated in the West Indies. It has about 25 per cent. of fixed oils and 2·5 to 5 per cent. of volatile oils. These latter contain mainly terpenes (pinene and camphene) and are the main odorous substances.

Pepper is the berry of a woody vine growing wild on the Malabar coast in India. It is also cultivated in Java, Sumatra, the Philippines and the West Indies. The chief centre of export is Penang. Black pepper is the berry picked before ripening and dried in the sun or over fires. White pepper is the fruit picked ripe from which the outer coat has been rubbed off. Black pepper is more pungent than white, and whereas white is the more popular in Europe, black is the pepper of choice in North America. The connoisseur prefers black pepper freshly ground to commercial preparations. Pepper owes its pungency to an alkaloid piperine, which, oddly enough when pure, is at first tasteless. Only on reaction with colloid substances on the tongue or elsewhere does it develop its characteristic pungency.

Saffron is the dried stigma of a crocus (*crocus sativus*) from the Middle East. As a spice or a colouring matter it is little used in this country except in Cornwall. It probably owes what flavour it has to a terpene and a tertiary alcohol.

Salt and sugar have already been considered in other places. Both are very important condiments in common use, in fact the most important condiments. It is almost accidental that they have important functions in metabolism. The condiment value of sugar is demonstrated by the way in which diabetics, as well as the general populace during the war of 1939–45, have recourse to saccharin (benzoic sulphamide) and dulcin (para-ethoxyphenylurea). These are non-metabolizable substances very much sweeter than sugar.

Vinegar is, or should be, the result of the oxidizing action of a group of microbes—*Acetobacter aceti*, *A. Pasteurianum*, *A. Kützingianum* and others [1]—on wine or malt liquor. On the Continent wines are used for the manufacture of vinegar but in this country malt liquor is usually the source. Sometimes the vinegar is distilled and the distillate contains acetic acid mainly along with traces of alcohols and esters. This vinegar is practically colourless.

The substance which gives vinegar its " bite " is acetic acid, while it is the substances present in the alcoholic liquor which give it its aroma.

In addition to these "natural" vinegars, there are on the market " artificial " and " spirit " vinegars. The former is made by diluting acetic acid, obtained from the destructive distillation of wood or otherwise, and adding colouring matter to match the colour of brewed vinegar. Spirit vinegar [2] is made from cane molasses which is diluted and fermented. The resulting alcohol is distilled off, mixed with ordinary vinegar and water and a " bacterial nutriment" and passed to "acetifiers." Here a secondary fermentation takes place and as the fluid comes from the acetifiers it contains as much as 12 to 13 per cent. of acetic acid. It is sold under the name of spirit vinegar. As it contains more than twice as much acetic acid as vinegar it is more pungent and pleasing to the debauched palate.

Vinegar is a condiment much used by urban populaces. It is said to soften the fibres of hard meat and salads, but it can have little use in diet other than stimulating appetite. In small amounts it cannot be considered harmful to the normal person, but its use is contra-indicated in the hyperchlorhydric and the patient with a peptic ulcer.

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[1] GALLOWAY and BURGESS. (1941), *Applied Mycology and Bacteriology.*

[2] *Analyst.* (1938), 63, 410.

There are various other flavourings and condiments which might be considered here—basil, bay leaves, marjoram, mint, parsley and thyme—but they are indifferently used in Great Britain, excepting for mint, parsley and thyme. The use of mint and parsley might with advantage be greatly extended because of their content of vitamin C and mineral elements.

During wars the possible value of the **edible fungi** receives attention but they have practically no food value except as condiments. Anyone who wishes to follow this by-way in dietetics should read the charmingly written and illustrated King Penguin book.[1] Practically the only fungus eaten generally in the British Isles is the mushroom, and in the north, the blewit as well. It is a matter of common knowledge that mushrooms are not easily digested and as a result of balanced experiments that they are not well absorbed—in fact they have little but an exquisite flavour to recommend them. The same may be said of truffles.

Analyses of raw and fried mushrooms show that they are of negligible food value, but serve as a vehicle for fat.[2]

	100 grammes contain										Cl.
	Protein.	Fat.	Available Carbo-hydrate.	Na.	K.	Ca.	Mg.	Fe.	Cu.	P.	
	g.		g.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Raw .	1·8	trace	0	9·1	467	2·9	13·2	1·03	0·64	136·0	84·0
Fried	2·2	22·3	0	11·0	565	3·5	16·0	1·25	0·78	166·0	103·0

[1] Ramsbottom. (1943), *Edible Fungi.*

[2] McCance and Widdowson. (1942), *op. cit.*

CHAPTER XVII

BEVERAGES

WATER

About two-thirds of the total weight of the body is made up of water. The importance of water as a tissue-builder and its right to rank as a true " food " are at once apparent from this statement.

The water in the body is " free," i.e. it is not chemically or physically so closely associated with the tissues that it cannot be removed by ultra-filtration. Ordinary solutes dissolve freely in it. The fluid in the intercellular spaces of the tissues, the body cavities, the lymph, and blood vessels contains predominantly sodium compounds. That within the tissues contains predominantly potassium. There can be free interchange of water between the tissues and the fluids which bathe the tissues (i.e. tissue fluid, lymph, and blood), but not of sodium and potassium. Anything which promotes free " circulation " of water from blood to tissue fluid and thence to the cells of tissues and out again is probably advantageous to cell metabolism, hence the value of drinking plentifully of water, of exercise, of perspiration, of massage and, perhaps, of Turkish baths.

The body is continually striking a balance between water intake and production in metabolism and water loss.

Water is gained by the body (i) by drinking, (ii) by eating moist foods, and (iii) by metabolizing proteins, fats, and carbohydrates. A mixed diet may contain per day as much as 1000 c.c. of moisture ; 400 c.c. may be produced by oxidizing proteins, fats, and carbohydrates.

The average loss to the body is about 450 c.c. through the skin, 300 c.c. in the expired air, 1500 c.c. in the urine, and 150 c.c. in the fæces, or a total of 2400 c.c. This leaves 1000 c.c. as a minimum which must be made up by drinking.

All these figures are, of course, averages only, depending upon the temperatures of the surrounding, the amount of exercise taken and the nature of the diet. If external temperature is high or exercise is great, much more water is excreted via the skin and the lungs, and if the water drunk is not increased, either the volume excreted in the urine will be decreased or the tissues dehydrated, or both. The importance of increasing fluid intake in such circumstances is obvious and fortunately it is usually automatically regulated by thirst. The loss in the fæces depends on the nature of the diet. If vegetarian, much more is lost by that path than if the diet is predominantly animal in origin.

Dehydration of the body occurs if not enough water is drunk, if there is persistent vomiting or diarrhœa or if there is a loss of electrolytes from the body as in vomiting due to pyloric stenosis (loss of chlorides) or as in Addison's disease (loss of sodium ions). The effects of dehydration are as follows: (i) thirst, (ii) loss of weight, (iii) disturbance of the acid-base equilibrium, (iv) rise in the non-protein nitrogen of the blood, (v) wrinkling of the skin, recession of the eyeball, etc., and (vi) rise of temperature.

On the other hand, excess of water *in the tissues* will produce a fall of temperature, vomiting, convulsions, coma, and death. This state of water intoxication is rarely likely to be seen in man, except possibly in the treatment of diabetes insipidus with pituitrin, when water consumption has not been decreased. It can easily be produced in animals by giving water by intubation and interfering with kidney excretion by injecting pituitrin.

The above facts have been cited to show that, while there is a distinct danger in drinking too little water, there is little or none in drinking much. We have stated above that the minimum daily intake with a normal diet, temperature surroundings, and a sedentary existence is 1000 c.c. or 1¾ pints. Much more can be taken without the slightest danger. So exact is the regulatory mechanism of the body, that two or three litres of water, taken on an empty stomach, will be excreted by the kidneys in the course of the next two or three hours without the concentration of the blood being significantly altered. The kidneys in such a case excrete practically distilled water.

Such water must pass from the bloodstream into the tissues to be stored there till excretion takes place. It is interesting to note that, according to Adolph, water taken on an empty stomach and passing as it does to the tissues, provokes a diuresis of greater volume than the fluid drunk. This may explain the observation, made by people taking strenuous exercise, that drinking water on an empty stomach leads to still greater thirst. Water taken with a meal is by no means rapidly excreted, a fact which should be utilized by cyclists, hikers, and enuretics. Diuretic drinks such as tea, coffee, alcohol, and to a less extent cocoa, may also increase thirst instead of assuaging it, if taken on an empty stomach.

We may sum up the practical results of the above considerations as follows:

(i) The minimum intake of water should be about 1¾ pints per day.

(ii) This can be greatly exceeded with advantage in evoking interchange between intracellular and extracellular fluid, without danger either to the normal person or the sick.

(iii) Water taken on an empty stomach may even increase thirst.

(iv) Except when taken in these circumstances, water is naturally the best thirst quencher, but if the stomach is empty milk is certainly better.

As we have indicated earlier, excessive perspiration in hot surroundings, or as the result of exercise, may deplete the body of sodium and in such cases the fluid taken to replace the water lost should contain salt.

Influence of Water on Digestion. The first point which it is necessary to emphasize in this connection is that ***water is not absorbed by the mucous membrane of the stomach.*** This is certainly a surprising fact, but it has been incontestably established both by physiological experiment and by observations on patients suffering from obstruction at the outlet of the stomach.

When water enters the stomach, it begins to flow out into the intestine almost at once. Roughly speaking, one may assume that a pint of water will have entirely passed from the stomach in the space of about three-quarters of an hour.[1] The precise rate of leaving, however, is very markedly influenced by temperature. Hot water escapes from the stomach much more rapidly than cold.[2] The heat increases powerfully the movements of the stomach walls, and at the same time seems to cause the pylorus to open, so favouring the escape of the contents. The stimulating effects which hot water exerts on gastric peristalsis render it a powerful aid to sluggish digestion, while the "unlocking" of the pylorus which it brings about is probably the explanation of the almost instantaneous relief which it affords in many cases of stomach pain.

The fact that water is exclusively absorbed in the intestine has important bearings on the treatment of patients suffering from dilated stomach. In the extreme form of that disease, when the stomach contents are quite unable to escape through the pylorus, the entrance of water into the blood is arrested, and the patient is the victim of a "tissue thirst," to which much of the emaciation and discomfort from which he suffers must be attributed. Not only is this so. The deficiency in the supply of water to the blood may go so far that the proper excretion of waste products is interfered with, and toxic symptoms, such as coma or convulsions, may then supervene. In such cases there is an imperious necessity for getting water into the blood *per rectum* or intravenously.

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[1] Moritz. (1894), *Münch. Med. Wochensch.*, **41**, 816.

[2] Schüle. (1895), *Zeit. f. Klin. Med.*, **28**, 461; (1896), *ibid.*, **29**, **49**.

The rapidity with which water passes through the stomach causes it to be a very dangerous vehicle of infection, for the hydrochloric acid of the gastric juice has no time to act upon any germs which it may contain. For this reason contaminated water is a more obnoxious carrier of disease than impure milk.

It is commonly said that the free consumption of water at meals is apt to delay digestion by diluting the gastric juice. This statement is not well grounded. Water is itself a slight, though unimportant, excitant of gastric secretion, and experiment has shown [1] that even in quantities of ½ litre (about a pint) it does not in any way affect the rapidity of digestion. Even 1 litre produces only slight slowing, while it requires quantities of 1½ litres (about 3 pints) to produce any marked effect.

On the other hand, it must be remembered that water may actually hasten the digestion of some foods by softening them and favouring their reduction to a state of pulp, while hot water is, as we have seen, a powerful stimulant of the stomach movements.

While foods may readily enter the blood when taken without water, none the less drinking at meals facilitates the process of absorption. (Adolph.)

Influence of Water on Metabolism. The influence of water on the chemical processes of the body would seem to be very slight. It was formerly believed that an increased consumption of water was accompanied by an increased waste of the nitrogenous tissues. This is now regarded as an error. Any increased excretion of nitrogen which a free consumption of water entails is ascribed, not to an increased breaking-down of the body substance, but to a washing-out of the tissues and the elimination of waste matters loitering in them.[2] This eliminative function of water is one of the first importance. It indicates the necessity for a free supply of that fluid in such diseases as gout, diabetes, and fevers, and in cases in which the excretory power of the kidney has deteriorated.

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[1] Miller, Bergheim, Rehfuss, and Hawk. (1920), *Amer. Journ. of Physiol.*, 52, 28.

[2] See Neumann. (1899), *Archiv. f. Hygiene*, 36, 248; Bergheim and Hawk. (1931), *Physiological Chemistry*, 601.

Varieties of Water. A good drinking water should have little or no colour, no odour, a pleasant, fresh taste, and should contain only a moderate amount of solid matter, 8½ grains per gallon being a good average. A tumblerful of ordinary London water contains only about one grain of solids. A wholesome water should contain very little organic matter, and that should be of vegetable origin, and if it has anything like a large proportion of chlorides it should be viewed with suspicion.

The amount of calcium salts which drinking water contains is a matter of some importance, and the relative merits of hard and soft water for drinking purposes have been much discussed. It has been maintained on the one hand that hard waters are apt to be productive, in those who habitually consume them, of such diseases as goitre and stone, while on the other hand it has been said that soft waters may favour the development of rickets. It must be admitted that neither of these contentions is very well founded, but it may be granted that it is well that the water one drinks should not contain more than 17 grains of calcium salts in every gallon, and that the sulphate of calcium is more likely to be harmful than the carbonate, for in some susceptible persons its presence may excite dyspepsia and diarrhœa.[1]

The fear that the use of soft water may lead to the development of rickets is quite groundless. When one remembers that even a hard water only contains about 0·002 grammes of calcium in every 100 c.c., and that an infant requires about 0·32 grammes daily, it will be evident that, as a source of calcium for the bones, water may be practically disregarded. On the other hand, there is no doubt that soft waters are more liable to become contaminated with lead than those which are richer in lime salts, and in that respect at least soft water may be a source of danger to health.

Mineral Waters

From time immemorial the sight of water gushing from the rock has appeared miraculous and numinous [2] and should the water be hot, as at Bath, impregnated with carbon dioxide as at Matlock, or have a strong odour or taste, as at Bath and Tunbridge Wells, medicinal powers are attributed to them. At one time and another it has been, and possibly again will be, fashionable to "drink the waters" at various "spas," up and down the country. There was once one in Bermondsey, London, S.E., and at Sadlers Wells, W.C.1. For those who could not go to "drink the waters" they have been bottled and distributed through Europe, and thus has grown up a considerable trade in "mineral waters." To-day, though we may discount their health-giving powers, they are a useful mild stimulant to the flow of gastric juice or may be used to neutralize "acidity," or as a substitute for local drinking water which may be under suspicion or unpleasant to drink because too highly chlorinated.

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[1] This is confirmed by the experience of three members of the family of one of us (V. H. M.) living during the war of 1939–45, in a part of Leicestershire where the content of calcium sulphate in the water is the highest we have met.

[2] The Roman name for Bath was Aquæ Solis.

Natural Mineral Waters. How far the majority of the mineral waters listed in previous editions of this book will be obtainable in the years after the war of 1939–45 is unknown as yet. The lists given there are here repeated in modified condensed form.

NATURAL MINERAL WATERS

Adonis. A mildly alkaline water containing 2·3 grammes sodium bicarbonate per litre, soft, well aerated, from springs in the Belgian Ardennes.

Appolinaris. An alkaline, highly aerated and slightly chlorinated water, containing sodium chloride and carbonates of sodium, calcium and magnesium, from a spring in the valley of the Ahr (Rhenish Prussia).

Arkina. A mildly alkaline Swiss natural sparkling water containing bicarbonate of magnesium.

Contrexéville. A slightly gaseous water containing 2·3 grammes of earthy carbonates per litre.

Johannis. A mildly alkaline, well-aerated water containing sodium chloride and carbonates of calcium and sodium, from the Johannis springs at Zollhaus, Nassau.

Perrier. A mildly alkaline, well-aerated natural water containing bicarbonate of soda mainly from Les Bouillens, Vergèze, in France.

Ramlösa. A mildly alkaline aerated water, containing no calcium or iron, from a spring in Sweden.

Rosbach. A mildly alkaline, well-aerated water containing bicarbonates of calcium and sodium and a small amount of sodium chloride from a spring near Homburg.

St. Galmier. A water containing 2·8 grammes solids per litre, mainly earthy bicarbonates.

Seltzer. A water containing 3·6 grammes solids per litre, including 2·24 grammes sodium chloride and 1·3 grammes of carbonates, from Nieder-Selters in Nassau.

Sinaro. A natural sparkling water, containing bicarbonates of calcium and sodium from Wiesbaden, Nassau.

Vichy. A water of high alkalinity with 8 grammes solid matter per litre, including 5 grammes of sodium bicarbonate.

The acid neutralizing power of one litre of five of these waters expressed as decinormal sodium hydroxide is as follows: Apollinaris, 367·2 c.c.; Johannis, 127·2 c.c.; Perrier, 60·0 c.c.; Rostach, 117·2 c.c.; Vichy, 558 c.c.

The dietetic advantages of the use of natural mineral waters may be presumed to be as follows. They have a pleasant, sharp taste due to the carbon dioxide with which they are impregnated, and there is evidence that that gas stimulates an early and abundant flow of gastric juice.[1] It also is said to stimulate gastric movement, while the bubbling of the gas through the stomach contents facilitates their disintegration.

The slight alkalinity of some of them renders them useful additions to the more acid wines, and also in cases of hyperchlorhydia.

On the other hand, when the stomach is dilated, when there is a tendency to flatulence or when the heart is functioning abnormally, they should be avoided.

Unfortunately it cannot always be claimed for the mineral waters that they are always sterile, though their makers are extremely careful in preparing them, treating the bottles into which they are put with greater antiseptic care than is necessary, say, for beer. Generally speaking recognized brands may be trusted to contain no pathogenic organisms.

Artificial Mineral Waters. The method of impregnating ordinary water with carbon-dioxide was discovered by Priestley in the latter half of the eighteenth century. Mineral waters can be made by charging water with the gas, which to-day is an article of commerce, either liquid or solid, under high pressure. Ordinary bottles of aerated water contain 3 or 4 volumes of gas to one of water; syphons contain more. When the pressure is released the carbon dioxide comes out of solution, but not all at once. In doing so it withdraws heat from the water, so that aerated waters are always cooler to the tongue than ordinary water kept under the same conditions.

The varieties of artificial aerated waters which call for mention are as follows:

1. ***Ordinary Water impregnated with Carbonic Acid Gas.*** The best makers obtain the water from springs or artesian wells, so that it is of great purity. Ordinary water so impregnated is

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[1] Penzoldt. (1902), *Deut. Arch. f. Klin. Med.*, 73, 200.

often, but erroneously, described as "soda-water." As soda is sometimes entirely absent, it is better to describe it simply as "carbonated water."

2. ***Aerated Distilled Water.*** In this case the water is distilled prior to being charged with gas. It is therefore entirely free from mineral matter and from all impurities. Examples of such water are sold under the names of "Puralis," "Salutaris," and "Globenaris."

3. ***Water to which Various Chemical Salts have been added,*** e.g.:

Soda water, containing 3 to 5 grains of sodium bicarbonate to the bottle.

Medicinal soda water, containing 15 grains of sodium bicarbonate ditto.

Potash water, containing 15 grains of potassium bicarbonate ditto.

Magnesia water, containing 12 grains of magnesium carbonate ditto.

Carrara water, containing 5 grains of calcium carbonate ditto.

Lithia water, containing 3 to 5 grains of lithium carbonate ditto.

4. ***Imitations of Various Natural Mineral Waters.*** One of the best examples of these is seltzer-water, which is intended to be a substitute for the natural water obtained from the Selters spring. Its ingredients are common salt, sodium bicarbonate, magnesium carbonate, and hydrochloric acid. By the interaction of these constituents an aerated water is produced which "gives a good imitation of the peculiar mellowness of genuine seltzer." An analysis of Schweppe's seltzer shows it to contain 24 grains of inorganic salts per imperial pint, or 12 grains per bottle. A tumblerful (5 oz.) has an acid-neutralizing power equal to that of 25 c.c. of decinormal soda or 100 per litre.

The question of ***natural** versus **artificial mineral waters*** must be decided entirely in favour of the former. For one thing, the natural waters do not contain any excess of gas, and a larger proportion of what they do contain is present in a combined form than is the case with the artificial waters. Hence their gas is given off more slowly, and they remain longer brisk, and are less apt to lead to sudden distension of the stomach. The following experiment bears this out:[1]

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[1] Analytical Reports. (1891), *Lancet*,

	Natural Water.	Artificial Water.	
Gas evolved .	480 c.c.	760 c.c.	Bottle opened and exposed for half an hour.
Gas remaining .	1010 c.c.	723 c.c.	
Total .	1490 c.c.	1483 c.c.	

There is also reason to believe that the effects of the salts in natural mineral waters are such as cannot be obtained from any artificial imitation of them. Zwaardemaker attributes important physiological actions to the radioactive elements, and these are sometimes found in the natural waters.

Soft Drinks. There is a large and popular group of beverages which includes lemonade, ginger-beer, *et hoc genus omne.* Mostly they consist of water sweetened with cane-sugar, rendered tart by the addition of an acid, flavoured in any way desired and finally charged with carbon dioxide. They are sometimes synthetic, but the trend in the best firms is to use flavourings extracted from root ginger and fresh fruits and a proportion of fruit juice in specific fruit drinks. We give a recipe for making the basis of one of the more aristocratic of these drinks.

Ginger-ale

Syrup (10 lb. sugar to 100 oz. of water) .	1 gallon
Compound tincture of ginger (or tincture of capsicum, 1 oz.)	4 oz.
Citric or tartaric acid	4 oz.
Colouring	½ oz.

1 to 1½ oz. of this mixture are added to a bottle which is then filled with water and aerated.

Genuine fermented ginger-beer (" stone-ginger ") is a very different product. A wort made from water, sugar, bruised ginger, tartaric acid and oil of lemon is fermented by yeast, as in the case of beer. It often contains 2 per cent. of alcohol and sometimes more.

Most of these drinks, synthetic or otherwise, are probably harmless, except to the palate. The same observations as made above concerning mineral waters apply to them when treating dyspepsia and heart troubles. Moreover it must not be forgotten that they contain about 30 grammes sugar to the bottle, and this must be taken into reckoning with diabetics.

Fruit Juices. In the United States the production of fresh fruit juices has risen to enormous dimensions within the past decade. The juices are expressed from the fruits by special machinery adapted to each fruit, clarified or not according to whether the flavour is carried mainly in the pulp particles, bottled and pasteurized. This preserves the fruit flavour and a large proportion of the vitamin C in the original fruit, and, of course, the sugar. These juices are extremely pleasant to drink and have great value in the sick-room. On the commercial side they are of value in making use of gluts of fruit and preserving the value of the fruit till another time. American soldiers in this country during the war of 1939–45 have much missed the soft drinks and fruit juices of their own country.

A small beginning has been made in this country in the supply of apple juice and blackcurrant syrup, though the price of the apple juice is 30 per cent. higher than that of the same quantity of bottled cider. From the dietitian's point of view this is unfortunate. The Medical Research Council's analyses of these fruit products is here given.

	100 grammes contain							Calories per oz.
	Protein.	Fat.	Carbohydrate.	Calcium.	Iron.	Vitamin A.	Vitamin C.	
	g.	g.	g.	mg.	mg.		mg.	
Blackcurrant syrup	0	0	46·0	20	2·0	—	55	52
Orange juice .	0	0	50·0	—	—	—	160	57
Rose-hip syrup .	0·6	0	50·0	—	—	—	150	58

It will be seen from these figures that fruit juices are quite useful for Calories and excellent for vitamin C. Apple juice will, of course, have much less vitamin C, and its main use is that of giving pleasure, along with a small amount of Calories, though claims have been made that it is useful in treating intractable diarrhœa. Its sugar content (expressed as invert sugar) is 8·5 per cent. and its acidity (expressed as malic acid) is 0·5 per cent.[1]

Tea, Coffee, and Cocoa. In four widely separated parts of the world man has discovered plants whose leaves or seeds, on extraction with water, yield stimulating drinks containing drugs of the methyl purine group. These drinks are tea, coffee, cocoa, and maté. Except for the last mentioned, these drinks have attained a world-wide popularity.

TEA[2]

History. The earliest credible mention of tea was made in A.D. 350 and the first handbook on the subject in A.D. 780, both of course in Chinese. Tea was introduced into Europe by the Dutch East India Company in the year 1610. As its price was at first ten guineas a pound, it can be readily imagined that it grew but slowly in popularity, and even in 1660 we find Pepys writing in his *Diary*: "I sent for a cup of tee, a China drink, *of which I had never drank before.*"

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[1] Private communication from Miss Olliver.

[2] The standard work on tea is *All about Tea* by W. H. Ukers. The Tea and Coffee Trade Journal (1935).

Up to the year 1862 nearly all our tea was obtained from China, the imports from that country reaching their maximum in 1879. Since that time the consumption of China teas has rapidly declined, their place being taken by Indian tea, and, since 1880, by teas grown in Ceylon.

Mode of Manufacture. The tea plant grows wild in Assam and attains a height of thirty feet, but it has been cultivated for centuries in China. The cultivated plant was called *Thea sinensis* by Linnaeus, who afterwards altered its name to camellia. Modern botanists, however, refer to both the wild and the cultivated plant as *Thea sinensis* and the camellia as *Thea Japonica*.

The plant "flushes" or sends out young shoots throughout the year in South India, Ceylon, Java, and Sumatra, but in North India, China, Japan, and Formosa the "flushes" occur roughly from spring to autumn only. A tropical climate is not essential for the cultivation of the tea plant.[1]

The young shoot has two small leaves at its tip which contain least fibre and most juice and therefore produce the finest sort of tea, but coarser pluckings, including three or even four leaves, are not rare (see Fig. 27). The terms Flowery Orange Pekoe, Orange Pekoe, and Pekoe now refer to the various grades of siftings. Flowery Orange Pekoe has many tips in evidence; the next finest is Orange Pekoe and after that Pekoe. The terms Pekoe Souchong and Souchong are used for teas containing coarser leaves.

The treatment of the leaves after they are picked varies according as black or green tea is to be produced.

For the production of ***black tea,*** the leaves are "withered," then rolled till they become soft and "mashy," (the object of this being to break up the fibre and cells of the leaf, and liberate the juices and enzymes) and then allowed to ferment. During the process of fermentation, some of the tannin in the leaves appears to be oxidized and converted into red, brown, and insoluble quinones,[2] while an essential oil seems to be produced, and a slight bitterness developed. After fermentation is complete the leaves are "fired" in a drying-machine.

[1] DANIEL HALL. *Our Daily Bread.*

[2] These substances are usually termed tannin, but unlike the tannin of oak, etc., they will not "tan" leather.

For the production of ***green tea,*** the fresh leaves are withered in hot pans at a temperature of 160° F. (Chinese method), or steamed (Japanese method). This destroys the oxidizing enzymes. Then they are rolled to break them up and liberate their juices; then "fired." Oolong teas are partially withered at ordinary temperatures before the enzymes are destroyed by heat.

It will be observed that the chief difference between black and green tea is that the former is fermented, while the latter is not; and one of the main results of fermentation seems to be to oxidize some of the tannin, so that, as we shall shortly see, an infusion of green tea contains more tannin than an infusion of black.

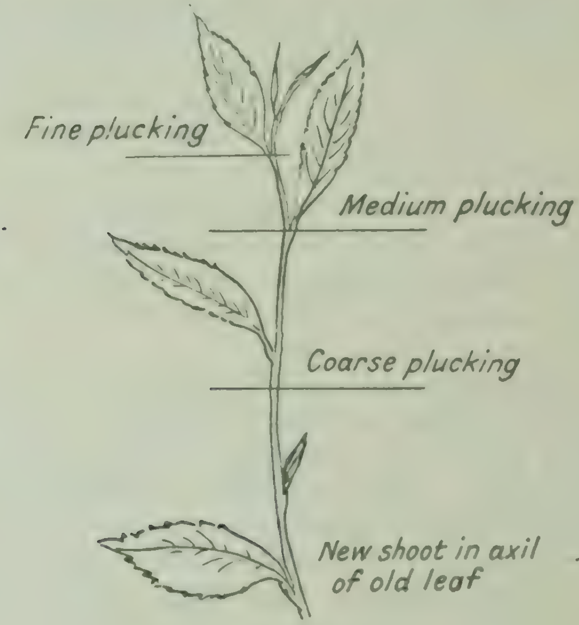

FIG. 27.

We have seen that the quality of teas varies with the age of the leaf from which they are prepared, the younger leaves yielding the finest tea. Apart from this cause of variation, teas show marked differences according to the country and district in which they are produced.

Chinese teas have the most delicate flavour of any, but are rather lacking in "body"; they are also devoid of any marked astringency, i.e. they have less tannin.

Indian teas, and especially those produced in Assam, have the greatest degree of "body" and astringency. This makes them powerful teas, suited rather for blending with milder varieties than for drinking alone.

Ceylon teas have plenty of body, and a rich and peculiar flavour, but have not so much strength or pungency as the Indian varieties. The best pluckings are made in February, March, August, and September.

According to the district in which they are produced, ***Chinese black teas*** may be divided into:

1. Monings, from North China, with a small and delicate leaf and a peculiar malty flavour. They are called in the trade Black leaf congous.

2. Kaisows, from South China, the so-called red-leaf teas, because the original teas grown in this district had a reddish leaf. These are the Red leaf congous of commerce.

3. Oolongs, from Formosa and China, are semi-fermented teas, pungent and slightly bitter, yielding a pale infusion, and chiefly used for purposes of blending.

4. Scented Orange Pekoe and scented Caper come from the Canton district. They are scented by adding white jasmine, gardenia, and magnolia flowers after the last firing and are allowed to stay in contact with these flowers for 24 hours. They yield a pale, strong infusion with an aromatic flavour, for which reason they are used to give bouquet to blends. Caper is an unfermented tea, highly fired, and standing intermediate between the black and green varieties.

Of ***Indian black teas,*** those from the Darjeeling district are best, being less rough and astringent than those from Assam, and well adapted for drinking alone. The best pluckings are made in June and October. It should be remembered that most black teas in the market are really blends of Indian, Ceylon, and China in different proportions.

Most ***green teas*** come from North China and Japan, the latter yielding the best. Very little is produced in India.

Other countries producing teas are Indo-China, Burma, Siam, Java, Sumatra, and Kenya. The U.S.S.R. are developing the cultivation of tea in the Caucasus.

In ***judging a tea,*** professional tea-tasters are guided by the nature of the liquor and the characters of the infused leaves or "out-turn."

The infusion should be of a reddish-golden colour, pungent in flavour, but not too bitter or astringent, and not "thin" or "hard."

The infused leaves should be of a bright coppery tint, and evenly extracted, so that some do not look darker than others; they should be uniform in size, and after five minutes' infusion should not be completely unrolled. There should not be too much stalk mixed with the leaves.

Chemical Composition of Tea. The following analyses of teas are given by Ukers :[1]

COMPOSITION OF TEA

	Per cent.
Water	5·0 – 8·0
Caffeine	2·5 – 5·0
Nitrogen	4·75– 5·5
Soluble matter	38·0 –45·0
Tannin	7·0 –14·0
Mineral elements	5·0 – 5·75

Of these ingredients, the most important are the alkaloid ***caffeine*** and ***tannin;*** for these, along with a small proportion of volatile oil (½ per cent.), are the ingredients to which the chief effects of tea on the body are due. The importance of the caffeine and tannin is so great that it may be well to bring forward some modern estimations of these ingredients in different teas which were made by Hosai.[2]

AMOUNT OF TANNIN AND CAFFEINE IN TEA (per cent.)

	Dried Leaf.	Green Tea.	Black Tea.
Crude Protein	37·33	37·43	38·90
,, Fibre	10·44	10·06	10·07
Mineral matter	4·97	4·92	4·93
Caffeine	3·30	3·20	3·30
Tannin	12·91	10·64	4·89
Hot-water extract	50·97	53·74	47·23
Ether extract	6·49	5·52	5·82
Total Nitrogen	5·97	5·99	6·22

Indian and Ceylon teas are richer in all the chief ingredients (caffeine, tannin, and volatile oil) than China teas. Green tea is richer in tannin than black, but the amount of caffeine in the two is almost the same. A high-grade tea contains both more tannin and more caffeine than a low-grade tea.

The ***composition of the infusion*** is of much greater practical importance than that of the leaves from which it is made.

If tea is infused for five minutes in the usual way, about 25 per cent. of the weight of the leaf goes into solution. In making a large teacupful of tea (about 150 c.c., or ¼ pint), 5 grammes (about ⅙ oz.) of dried leaf are usually employed, and a cupful of such tea contains in solution about 1 gramme of solid matter. The bulk of this is made up of gummy matters, extractives, etc., but the most important ingredients are the caffeine, and tannin.

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[1] UKERS. *op. cit.*, 1, 511.

[2] Quoted by UKERS. *op. cit.*

Of these two ingredients the caffeine comes out much more readily than the tannin, and the result of this is that second cups made from a further extraction of the leaves, as is the usual practice, contain much less of the stimulant and more of the astringent than the first cup. An illustration of this is seen in the comparison of the effect of 5 minutes' infusion compared with one hour's boiling.

	5 mins. Infusion.	1 hour's Boiling.
Tannin	7·3	12·4
Caffeine	3·6	4·8
Soluble extract . . .	23·2	44·5

The practical inference is that, if we wish to avoid having much tannin in tea and yet a high proportion of caffeine, we should infuse it but for 5 or 6 minutes and then pour off the infusion into another teapot. If less tannin is desired, 3 minutes' infusion is better.

Hutchison made a number of experiments with the view of determining the amount of caffeine and tannic acid present in an ordinary teacupful of tea infused in the usual way. The results are contained in the following tables :

Caffeine in Teas[1]

Tea.	Caffeine in Grammes per 150 c.c			
Ceylon Pekoe	0·0787	equals	1·21	grains
Fine Darjeeling . . .	0·0751	,,	1·15	,,
Common Congou . . .	0·0745	,,	1·14	,,
Moyune Gunpowder (green) .	0·0645	,,	0·99	,,
Imperial Gunpowder . .	0·0590	,,	0·90	,,
Household blend . . .	0·0580	,,	0·89	,,
Young Hyson . . .	0·0547	,,	0·84	,,
Fine Moning	0·0510	,,	0·78	,,
Fine Assam	0·0475	,,	0·73	,,

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[1] Eight grammes of dry leaf were infused with 300 c.c. boiling water for five minutes. The caffeine was estimated by Allen's method, and the tannin estimated by Procter's modification of Löwenthal's process.

TANNIN IN TEAS

Tea.	Tannin as Gallo-tannic Acid per 150 c.c. of Infusion.			
Moyune Gunpowder	0·273	equals	4·20	grains
Young Hyson	0·242	,,	3·72	,,
Imperial Gunpowder	0·227	,,	3·49	,,
Ordinary black blend	0·173	,,	2·66	,,
Fine Darjeeling	0·168	,,	2·58	,,
Good black blend	0·168	,,	2·58	,,
Ceylon Pekoe	0·142	,,	2·18	,,
Lapsang Souchong	0·087	,,	1·33	,,
Fine Assam	0·080	,,	1·23	,,
Fine Moning	0·058	,,	0·89	,,

As a rule, one may say that a teacupful of tea of ordinary strength infused for five minutes contains about 1 grain of caffeine, and from one and a half to three times as much tannin.

It may be well to give some practical ***rules for the proper method of making tea*** based on the facts as to its chemistry which we have just been considering. This is all the more important as it is comparatively rare to get a really good cup of tea, in spite of the popularity of the beverage. It must be admitted, too, that the fault lies oftener with the method of infusion than with the quality of the original leaf employed.

And, first, the tea should really be ***infused,*** i.e. boiling water should be poured on the leaves and allowed to stand thus for five minutes. The character of the water is of the first importance. The Chinese rule is "Take the water from a running stream ; that from hill springs is best, river water is the next, and well water is the worst." The experience of one of us is, that in this country rain water is the worst, soft moorland water the next worst, and water of the hardness of London water the best for tea making, though tea dealers do not necessarily agree. The water should have just come to the boil. "The fire must be lively and clear, but the water must not be boiled too hastily. At first it begins to sparkle like crabs' eyes, then somewhat like fishes' eyes, and lastly it boils up like pearls innumerable, springing and waving about" is the quaint advice of the Chinese.

The quantity of leaf infused demands some attention. The domestic rule of "a teaspoonful for each person and one for the pot" is an uncertain one, for the weight of a spoonful of tea is a very variable quantity depending on the size of the leaves and the tightness with which they are rolled.

Tea-tasters use the weight of a new sixpence (43½ grains or

2·9 grammes) to 3½ oz. of water, and this, which is a somewhat smaller proportion of tea than that given by the domestic rule, yields a more satisfactory though weaker infusion. It must be remembered, however, that the popular taste is for a strong beverage with a good deal of "body."[1]

The use of a "cosy" during infusion does no harm, but as soon as the process is completed the liquor should be poured off into another hot teapot, which may then be kept covered if desired.

The addition of milk or cream, though an outrage in the eyes of connoisseurs, is to be commended on hygienic grounds, for the protein of the milk, combining with the tannin, forms an insoluble compound.

All second brews should be avoided, for a single infusion is sufficient to remove from the leaves all the useful constituents of the beverage.

COFFEE

Coffee was introduced into this country in the year 1652, by a certain Mr. Daniel Edwards, a retired Smyrna merchant, who set up his Greek servant in a coffee-house, the first of its kind in London, in St. Michael's Alley, Cornhill.[2] As a beverage it has never attained the popularity with us that it has won on the Continent. This may be explained partly, perhaps, by the fact that we do not know how to make coffee, but mainly by its greater expense when compared with its principal rival, tea.

Coffee is derived from the "Coffæa arabica," originally produced, as the name implies, in Arabia, but now cultivated in many tropical countries. The plant produces three harvests annually, the fruit resembling a cherry, in which the "coffee-bean" corresponds to the stone. The bean consists of two halves placed face to face and enclosed in a husk. The pulp is softened by fermentation and removed, and the beans, still enclosed in their husk, are dried in the air. The husk is separated by rolling, and the beans are then separated from the delicate parchment-like skin which covers them, and assorted according to size.

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[1] For the economical preparation of good tea the thorough crushing of the leaf is of great importance, so that its ingredients may readily be extracted. The powdered tea of Japan is ideal in this respect, and in this country "tea tabloids" are deserving of a word of praise for the same reason.

[2] According to UKERS (1935), *All About Coffee*, The Tea and Coffee Trade Journal Co., Oxford anticipated London by two years.

Varieties of bean are found on the market, the chief being as follows:

1. ***Mocha.*** The genuine beans of this are derived from Arabia, the best from the Beni-Mattar country. The beans are small, hard, round, and irregular in form and size, olive-green to pale yellow in colour. The roast is poor and irregular. In the cup Mocha has a heavy body and smooth and delicious flavour. (Ukers.)
2. ***Mysore.*** A general name for Indian beans. The bean is small to large, blue-green in colour. It yields a strong flavour and deep colour.
3. ***Kenya.*** Beans small and roundish with blunt ends, and of a greenish colour. The liquor is "mild," with full body, and of a flavour between that of Mysore and Costa Rica.
4. ***Costa Rica.*** A blue-greenish berry yielding a fine, mild-flavoured liquor, rich in body.
5. ***Java.*** A very fine coffee, with blue to pale yellow beans, yielding a smooth, light-coloured liquid.
6. ***Sumatra.*** The finest coffee the world produces. Large uniform green beans. Smooth heavy body, almost syrupy.
7. ***Brazil.*** 60 to 70 per cent. of the world's coffees come from Brazil, and 45 to 50 per cent. from the Saõ Paulo district. Small bean resembling Mocha. Smooth, acid, and pungent in the cup.

In order to prepare the beverage, the berries must first be roasted. The **composition** of raw and roasted coffee is contrasted by Triggs, quoted by Ukers.

Composition of Coffee

	Mocha.	
	Green.	Roasted.
Caffeine	1·3	1·28
Water extract	31·27	30·44
Fat and oil	14·04	14·18
Protein	8·56	9·57
Crude Fibre	22·46	15·41
Mineral elements	4·20	4·43
Moisture	9·06	3·36

The chief physical change which results from roasting is that the berries are rendered brittle and can now be ground. Chemically, one finds that they lose considerable weight, the loss consisting in nearly equal parts of moisture and organic matter. The lost organic matter includes some of the caffeine.[1] If the coffee is "over-roasted," the loss of caffeine may be considerably greater.

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[1] The fat is not much affected according to Bengis and Anderson. (1934), *Journ. Biol. Chem.*, **105**, 139 (quoted by Ukers). The Polenske and Reichert–Meissl figures rise.

The aromatic substances which give its attraction to coffee are many, probably mainly heterocyclic mercaptans.

Composition of the Infusion. From 25 to 35 per cent. of the coffee used in making the infusion goes into solution. This percentage of solubility is about the same as that of tea, but seeing that a much larger quantity of coffee is taken than of tea, the amount of solids per cup is considerably higher in the former than in the latter beverage. If 2 oz. are used to make a pint,[1] a teacupful of the beverage will contain in solution about 4·2 grammes of solids, of which 0·65 is mineral matter. This is supposing the coffee to be filtered. As ordinarily drunk, some suspended matter must also be included.

An analysis made by Hutchison of coffee of the above strength, showed the presence of 1·7 grains of caffeine per teacupful, and 3·24 grains of tannin.[2] According to this result, a cup of black coffee contains very much the same amount of caffeine and tannic acid as an equal quantity of tea. A breakfast-cupful of ***café au lait*** is composed of about 1 part of black coffee to 3 of milk, and will not, therefore, contain more of the alkaloid than a teacupful of tea.

French coffee demands a special word of mention. It usually contains more or less chicory, and sometimes also some burnt sugar. Chicory is the root of the wild endive, kiln-dried and broken into fragments. The process of drying converts its sugar, of which it may have 10 to 18 per cent., into caramel. There is no reason to believe that chicory is in any way injurious to health, but its cheapness is a great temptation to use it as an adulterant, a process which has done much to discourage the consumption of coffee in this country. As a rule, French coffee contains about one-third of its weight of chicory, but sometimes the proportion may be as high as 80 per cent., or even more.

The secret of having good coffee is to make it ***strong*** and to make it ***hot***. We mostly fail in this country by not using enough. One ounce to the pint is the smallest proportion which will give a good result. It is important that the coffee should be freshly roasted, or if bought roasted it should be bought in small vacuum sealed tins. If the beans are roasted and ground at home, they should be of one size or they will be unequally fired. Blending or mixing should be done after roasting. Its fragrance is quickly dissipated on keeping. Care also must be taken that the grinder is quite clean, for if *any stale coffee is left in it the whole may be spoilt.* The best way of making coffee is to extract the freshly roast and ground coffee overnight with *cold* water, strain it and rapidly bring the extract to a temperature at which it is worth drinking. Boiling an infusion alters the flavour. The usual way is to pour boiling water over the freshly ground coffee. The water should be just boiling, and infusion may be carried out either in a jug or in a porcelain percolator. For breakfast coffee a mixture of coffees—e.g. half and half Mocha and Plantation—may be used, and the addition of a little ground chicory is liked by some, but for black coffee the latter should always be omitted. Three parts of milk to one of coffee is about the proper proportion for ***café au lait.***

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[1] One ounce of coffee to the pint is usually, however, regarded as enough to make a satisfactory beverage.

[2] Reckoned as gallo-tannin.

Cocoa

Cocoa was first brought to Europe from Mexico by the Spaniards early in the sixteenth century.[1] It was known as "cacao," but the name got changed with the lapse of time. Although introduced considerably earlier than either tea or coffee, it is only of late years that it has attained any wide popularity, and that chiefly through the energy and enterprise of some of its manufacturers.

The cocoa-plant is the "Theobroma cacao," the fruit of which resembles a vegetable marrow or cucumber. Embedded in the pulp of the fruit are many seeds, each about the size of a haricot bean, and it is from these that cocoa is prepared. The seeds are separated from the pulp, and placed in heaps for several days to ferment, or "sweat."[2] This causes any adherent pulp to become loose, and at the same time modifies the bitterness of the seeds and produces in them a dark colour. They are then roasted, which renders them brittle and loosens the husk, so that the two halves of the seed come out separately on pressure in a machine as ***cocoa-nibs.***

The nibs are either sold as such or are ground between hot rollers, which, by melting the fat that they contain, reduces them to a fluid condition. Much of the fat is removed by pressure, and the remainder of the cocoa is then run into moulds, from which it is removed as slabs. For conversion into "soluble cocoa" or "cocoa essence" the slabs are ground to an impalpable powder.

Various names are applied to different preparations of cocoa. The method of preparing ***soluble cocoa*** has just been described; but it should be noted that the term is really a misnomer, for, strictly speaking, there is no such thing as a soluble form of cocoa. All that the term implies is that the powder is so finely divided that it easily remains in a state of suspension when mixed with water. In order to aid the suspension, various methods of treating the cocoa are sometimes adopted. The addition of alkali such as sodium carbonate is a favourite device, especially with Dutch manufacturers. It aids suspension by saponifying and emulsifying the fat, and at the same time softens the fibre of the cocoa, so that it can form a sort of pulp with water. It also has the effect of deepening the colour of the beverage, and so of making it look stronger. The free addition of alkali is objected to by some as being injurious to health, but it is very doubtful if that can be fairly alleged against it. There are also methods of increasing the solubility of cocoa by the aid of heat, and to these no objection can be urged.

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[1] For a history of Cocoa see *The Food of the Gods*, by Brandon Head (George Routledge and Sons, Ltd.).

[2] If this is done in tropical sunlight the yeasts which cause the fermentation become endowed with vitamin D, which may ultimately appear in the cocoa.

The term ***homœopathic cocoa*** was originally applied to mixtures of cocoa with starch.

Malted cocoa is a combination of pure cocoa with extract of malt.

Chemical Composition of Cocoa.[1] The general composition of the cocoa-bean is shown in the following table.

COMPOSITION OF COCOA

	Analysis of Raw Trinidad Nibs.[2] Per Cent.	Analysis of Shelled Fresh Cocoa-beans.[3] Per Cent.
Water	5·23	7·6
Fat	50·44	49·9
Starch	4·20	2·4
Albuminous matter, soluble	6·3	10·9
,, ,, insoluble	6·3	
Astringent principle	6·71	0·2
Gum	2·17	2·4
Cellulose	6·40	10·6
Alkaloid	0·84	3·3
Cocoa-red	2·20	
Undetermined	5·80	5·3
Mineral elements	2·75	4·0

The chief ingredient is fat, of which the cocoa-bean contains about half its weight. In the commercial powder, however, there is only about 30 per cent. present, the remainder having been removed by pressure.

Cocoa contains a considerable proportion of nitrogen, but it must be carefully noted that not all this represents protein. Part also is contained in theobromine.

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[1] See also ALLEN'S *Commercial Organic Analysis*, 3, Part 2.

[2] Inland Revenue Laboratory.

[3] Boussingault.

The chief alkaloid found in cocoa is theobromine.[1] ***Theobromine*** is known chemically as dimethyl-xanthine, and it is closely related to caffeine, which is trimethyl-xanthine. Cocoa contains from 1 to 2 or more per cent. of it, or about as much as there is of caffeine in coffee.

Cocoa contains also some tannin, though probably not of exactly the same form as that found in coffee and tea. It seems to be combined with a pigment to which the name of cocoa-red is given, but the exact relationship of the two substances has not been fully determined.

Starch is present to the extent of 8 per cent. (Winton, Silverman, and Bailey).[2]

The proportion of mineral elements is high, amounting in raw cocoa to from 2½ to 3½ per cent. Copper and manganese are present and iron 2½ to 3½ milligrammes per 100 grammes. After the fat has been partly removed, the proportion of ash rises to 4 or 5 per cent.; or, if alkali has been artificially added, it may amount to 8 per cent. The ash is strongly alkaline, and in the artificial preparations consists chiefly of potash and phosphoric acid.

Chocolate consists of ground cocoa-nibs to which cocoa butter is added, together with cane-sugar and vanilla flavouring. The inferior varieties are made from unfermented beans, and therefore have a bitter taste. Good chocolate should melt easily in the mouth, and should not sweat out any sugar in the form of a bloom. The taste also should be free from any roughness or astringency. The white part of chocolate creams consists of a mixture of cane-sugar and glucose.

The table on the opposite page shows some analyses of cocoas, drinking and eating chocolate.

Uses of Tea, Coffee, and Cocoa

Tea contains caffeine (1,3,7,trimethyl-xanthine) and theophylline (1,3,dimethyl-xanthine);[3] coffee, caffeine; and cocoa, theobromine

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[1] Analyses in 1935 from the laboratories of Fry & Sons show the presence of caffeine:

	Beans.	Cocoa.	Plain Chocolate.	Milk Chocolate.
Theobromine	1·04 (0·82–1·32)	1·5	0·3	0·15 per cent.
Caffeine .	0·4 (0·14–0·73)	0·6	0·1	0·05 ,, ,,

[2] Quoted by Winton and Winton. (1939), *The Structure and Composition of Foods.* Chapman & Hall, Ltd., 4, 121.

[3] Also tetramethyluric acid (tetramethyloxyxanthine).

			hydrate.		Caffeine.	per oz.	
Bournville cocoa . . .	18·1	26·5	36·0*	7·7	2·3	134	A typical modern cocoa powder.
Cup chocolate	5·3	19·4	71·1†	1·4	about 0·4	140	A drinking chocolate in flake form.
Red Label chocolate . .	6·1	6·9	82·5†	1·6	,, ,,	121	A drinking chocolate in powder form.
Bournvita	13·1‖	8·1§	72·3‡	3·0	—	120	Combination of malt, milk, egg, and chocolate powder.
Cocoa and milk powder .	12·1‖	5·7§	76·2‡	3·3	about 0·4	118	A sweetened blend of cocoa and milk solids.
Bournville chocolate . .	4·1	32·5	59·9†	1·2	0·4	160	Eating chocolate.
,, milk chocolate	8·0‖	35·0§	53·0‡	2·0	0·2	161	Eating chocolate.
Rowntree's Elect cocoa .	17·1	24·0	39·6¶	7·7	2·3	130	An alkalized cocoa essence.
,, plain chocolate	4·8	32·6	60·8	1·3	0·57	146	Made from cocoa-nibs, sugar, and added cocoa butter.
,, milk chocolate	8·3‖	33·5	55·1	1·7	0·18	146	Cocoa-nibs, sugar, full cream dried milk, and added cocoa butter.
Fry's plain chocolate . .	3·4	32·1	61·4†	0·8	0·5	160	3 per cent. of the fat is butter fat. 1 I.U. vitamin D per gramme chocolate.
,, milk chocolate . .	8·2‖	33·7	55·2‡	1·6	0·2	162	Vitamin A = ¼ that of early summer butter. Vitamin D 9 I.U. per oz. chocolate.
Breakfast cocoa . . .	17·4	23·0	39·8	7·4	2·9	126	
Malted milk cocoa with eggs	14·8	8·6	67·7	3·9	0·6	119	
Supex chocolate . . .	5·6	35·3	46·5	1·4	—	152	Free from cacao shell or starch and added alkali. Of good texture, free from astringency and bloom. (*Lancet*, 1922.)
Vienna drinking chocolate	5·1	6·8	82·0†	1·8	0·9	119	

* Starch, dextrins, etc. † Cane-sugar added. ‡ Inclusive of lactose and cane-sugar.
§ Inclusive of lecithin and milk fat. ‖ Inclusive of milk protein. ¶ Cocoa-starch, pentosans, etc.

(3,7,dimethyl-xanthine). Of these, much the most active and important is caffeine.

Caffeine is a stimulant which affects the nervous system and the kidneys. In the nervous system it influences the higher "psychic" centres more than the medullary centres and these more than the spinal cord. Pavlov states that it is impossible to inhibit conditioned reflexes when the animal is under the influence of caffeine, and the alkaloid has therefore an effect on the cortex of the brain. It undoubtedly "clears the mind," abolishes a sense of fatigue and often induces sleeplessness. Tea and coffee certainly are great aids to mental work, and the former, as de Quincey remarked, will always be the beverage of the intellectual. For panegyrics on tea and coffee and legends concerning the discovery of these plants the reader is referred to earlier editions of this book and to the books by Ukers.

Respiratory and cardiac centres are also stimulated by caffeine and there is a direct effect on the coronary arteries, which are dilated. The basal metabolism of a group of coffee drinkers was found to be 6 per cent. higher than that of a control group of abstainers from coffee.[1] It is also said to raise the blood-sugar level. As a result of the quickening of respiration, the alveolar carbon dioxide is lowered. Apart from its action in improving the circulation of blood it causes diuresis by direct action on the kidney. It decreases the reaction time and the latent period of reflexes and stimulates the capacity for muscular work.[2] It is not cumulative nor habit forming, and it has no after effects. The other purine derivatives have rather less effect than caffeine, but the action is similar.

Clearly these alkaloids are extremely useful and their effects account for the very extended use of the beverages containing them by people in all ages and countries. On the other hand their pharmacological properties are too mild seriously to interest pharmacologists and clinicians to-day, for much more potent drugs have been discovered.[3]

The common practice in this country among the well-to-do is to take tea at afternoon tea only, and coffee at breakfast, after lunch, and after dinner. Nearly everyone lower in the social scale takes tea at breakfast and in the afternoon and possibly before breakfast, at midmorning, after the midday meal, with the evening meal and perhaps just before bed. In Canada, and probably in other Dominions, it is drunk with each of the three meals.

[1] Hackett. (1931), *Journ. Home. Econ.*, **13**, 769.

[2] Rivers and Webber. (1907), *Journ. Physiol.*, **36**, 33.

[3] The late A. J. Clark. Private communication.

There is a strong medical prejudice against taking tea with any meat meal in Great Britain, and the belief is entertained that the tannin in the tea "tans" the protein of the meat and makes it indigestible. But no objection is raised to the tanning of the protein of fish and eggs at breakfast, which must be almost as serious, nor to the effects of tannin in coffee or wine. Attempts have been made to justify objections to the taking of tea and coffee at meals by experiments *in vitro* and *in vivo.*

Thus *in vitro* the presence of tea inhibits the digestion of boiled starch to maltose by the ptyalin of the saliva. This inhibition seems to be due to the tannin, for it is less with a good China tea than with an Indian tea, with its higher content of tannin, and the effect disappears entirely if milk be added, which combines with the tannin and puts it out of action. When the tannin[1] is in combination with the caffeine and not free it is said to exert less effect in precipitating and rendering protein insoluble.

In vivo it has been claimed by a succession of workers that tea and coffee delay peptic digestion, although Miller and his colleagues[2] found that the emptying of the stomach is not appreciably delayed by 1 litre of tea or coffee, and that a delay apparently caused by an equal quantity of cocoa is due to the sugar normally taken with it.

As regards the practical inferences to be drawn from these and similar experiments, it may be said that in health the disturbance of digestion by these infused beverages is negligible. Only when the digestion is enfeebled or when the patient is sensitive to tea or coffee is caution necessary. It is usual to restrict the consumption of tea and coffee in gastritis, gastric and duodenal ulcer. It may be wise to forbid coffee entirely and recommend that weak China tea, freshly infused and poured off the leaves, be taken at the end of the meal in its place not more than twice a day. These beverages should not be taken on an empty stomach.

When we turn to the question to what extent these beverages can be indulged in without injury to health, we find it very difficult to give a definite reply. The part played by personal peculiarity and habit in the matter is very great. It has been pointed out, for example, that the usual result of drinking tea and coffee is to produce wakefulness, but yet there are persons who find their use in the evening conducive to sleep. Some people, again, can drink tea quite freely, but are made ill by coffee, or *vice versâ.* Facts like these must be recognized although one is unable to explain them, and they make it impossible to lay down definite rules regarding the dietetic use of tea and coffee.

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[1] Hijât tea contains all its tannin as caffeine tannate according to analyses by the Royal Institute of Public Health and Hygiene.

[2] MILLER *et alii.* (1920), *Amer. Journ. Physiol.,* 52, 28.

The bad effects usually attributed to an excessive indulgence in these beverages are of two kinds affecting either the nervous system or the digestion. The increased excitability of the nervous system which they produce may lead to general " nervousness " (the patient starts, for instance, on the slightest sudden noise, or, as a tea-taster once put it, he becomes " jumpy "), tremulousness, palpitation, loss of sleep, giddiness, and depression. The nervous system in childhood and after middle life is peculiarly susceptible to these effects.

The disturbance of digestion which tea or coffee, but especially the former, produces may be partly due to a direct interference with the chemical part of the process, as already described, but in part also may be brought about indirectly through the nervous system. The dyspepsia which results is of the atonic type, digestion being slow, often accompanied by flatulence and attended by a feeling of sinking or depression and disturbance of the heart's action.

Whilst one may fully admit the importance of the part played by tea and coffee in the production of such symptoms, yet the extent to which they prevail has probably been greatly overestimated. It certainly seems an exaggeration to talk, as some people do, of the existence of " tea drunkenness." All that one is entitled to infer is that these beverages should be used sparingly by " nervous " people and by those whose digestion tends to be feeble and slow.[1]

It was once the practice to forbid gouty patients to drink tea and coffee, as caffeine is a source of uric acid, but this is very rarely necessary (p. 613).

The place of ***cocoa*** in the diet is not really very different from that of tea and coffee. An examination of the chemical composition of cocoa might lead one to suppose that it was of considerable nutritive value.[2] But that would be a mistake. Theoretically, cocoa is a valuable food, but practically it is not, the reason being that so little of it can be taken at a time. In this respect it is exactly comparable to many of the beef-extracts already considered. The combination of cocoa with casein—as in ***Plasmon Cocoa***—increases the nutritive value of the beverage.

It takes about 10 grammes ($\frac{1}{3}$ oz.) of cocoa to make a breakfast-cupful of the beverage, and, assuming the average composition given already, this would yield about 40 Calories of energy. It would, therefore, require fully seventy-five such cupfuls to yield the total amount of potential energy demanded of the body daily—obviously an impossible quantity. Of course, if the beverage is prepared entirely with milk and plenty of sugar it becomes an important food, but that is due to the milk and sugar, and not to the cocoa. Chocolate is of more value. Half a pint of milk and 2 oz. of chocolate yield together fully 400 Calories, and 3½ pints would suffice to supply all the energy and a large part of the building material required in a day.

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[1] See also the chapter " Caffeine Beverages," by Prof. W. E. DIXON, (1930), in *What We Drink* (London, Wm. Heinemann (Medical Books), Ltd.).

[2] For the unimportance of cocoa and chocolate as sources of protein, see MITCHELL, BEADLES and KEITH. (1926), *Journ. Biol. Chem.*, 71, 15.

The action of cocoa on the nervous system is very much less than that of tea or coffee, owing to the small amount of alkaloid which it contains; indeed, it may be practically ignored.

PARAGUAY TEA

Paraguay tea or maté is the dried leaves of *Ilex paraguayensis* which belongs to the Acquifoliaceæ. It contains 1–2 per cent. of caffeine along with tannin, volatile ether extract, resin, and sucrose. It yields a pale infusion of somewhat bitter and harsh flavour. It is stated to be even more stimulating and sustaining than tea or coffee, and less apt to cause indigestion and sleeplessness.

Owing to the injurious effects of tea and coffee on the digestion and nervous system in some persons, various substitutes for them in the diet have been proposed. Amongst these are ***Ovaltine,*** which is composed of malt extract, milk, eggs, and cocoa, and contains a considerable percentage of lecithin. It has 8·01 per cent. fat, 67·9 per cent. of carbohydrates, 14·2 per cent. protein, and 1·18 per cent. mineral elements. Fry's ***Malted Milk Cocoa with Eggs*** and Cadbury's ***Bournvita*** are preparations of a similar type.[1] ***Glaxovo*** consists of dried milk, cocoa, cane-sugar, wheat flour, vitamins A and D, and iron. ***Colact,*** also made by Glaxo Laboratories, has a similar make-up. It contains 20·5 per cent. protein, 18 per cent. fat, 54·5 per cent. carbohydrate and 65 I.U. vitamin D per oz. ***Vitone*** uses soya bean milk as a basis. ***H.A.G. Coffee*** (coffee from which the caffeine has been extracted) and ***Cocacorn*** (a combination of acorns and cocoa) are other tea and coffee substitutes. Various ***Cereal Coffees,*** made from parched grains of barley, wheat, etc., are also prepared, especially in America. ***Instant-Postum*** is an example. One or other of these substitutes is sometimes found of use in replacing tea or coffee when these are forbidden on medical grounds.

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[1] Also they are pleasant to eat, dry, with cream.

ALCOHOL AND ALCOHOLIC BEVERAGES

The only form of alcohol with which we are seriously concerned in dietetics is ethyl alcohol (C_2H_5OH). It is produced, in most of the beverages in which it is found, from the fermentation of glucose by yeast, according to the well-known equation :

$$\underset{\text{(glucose)}}{C_6H_{12}O_6} = \underset{\substack{\text{(carbonic}\\\text{acid)}}}{2CO_2} + \underset{\text{(alcohol).}}{2C_2H_5OH.}$$

We shall subsequently discover that the special characters of different alcoholic beverages depend to some extent on the particular substrate and yeast concerned in the fermentation. It must also be borne in mind that the process of fermentation as carried on in the manufacture of alcoholic drinks is never such a simple affair as the above equation might induce one to believe. By-products are invariably produced as well as alcohol, and the nature and amount of these profoundly influence the character of the resulting beverage. Of all alcoholic drinks, however, it remains true that the principal constituent by which they affect the body is ethyl alcohol. It consequently becomes of the first importance for us to study the effects of alcohol on the body, for upon the results of such study our opinion as to the value or otherwise of alcoholic drinks, both in health and disease, must ultimately rest. We propose, therefore, to devote this section to a description of the physiological effects of alcohol.[1]

Local Effects of Alcohol. The local effects of alcohol are those of a chemical irritant. If some strong spirit, such as whisky or brandy, is taken into the mouth, a sensation of burning is produced, owing to the irritation of the nerve endings, and by and by the mucous membrane becomes somewhat corrugated and whitened by reason of the removal of water from its surface cells and the coagulation of their protoplasm. Repeated local irritation of this sort is the exciting cause of the pharyngitis and gastric catarrh often observed in those who are in the habit of drinking neat spirits, especially on an empty stomach, where the alcohol can come into direct contact with the mucous membrane. The stimulation of the nerves of the mouth brings about reflexly a profuse flow of saliva, and in this way alcohol may promote salivary digestion, for its retarding influence in the chemical transformation of starch into sugar is so slight that it may be neglected.[1]

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[1] For a detailed account, see *Alcohol: its Action on the Human Organism*, Third edition (1938). H.M. Stationery Office.

Effects of Alcohol on Digestion. There are three things to consider when alcohol enters the stomach: (1) its influence on the amount and nature of the secretion, (2) its influence on the movements of the stomach walls, and (3) its influence on the rate of digestion.

1. It increases the flow of gastric juice, but such juice as is secreted, is almost devoid of pepsin, though the normal amount of hydrochloric acid is produced. The greatest amount of secretion occurs when the dose is small and the concentration of alcohol does not rise higher than 10 per cent. Stronger and larger doses evolve less secretion of juice and mucus is formed in increased amount. Repeated doses increase the mucus and decrease the gastric juice still further.

2. There is no reason to believe that there is increased activity of movement. Chittenden found that the stay of food in the stomach of a dog was not materially altered by alcohol. Carlson found that 2–4 oz. of 10 per cent. alcohol abolished hunger contractions for two hours, and half a pint of beer for half an hour. In fact alcohol shares a carminative action on the stomach activities with many other volatile substances.

3. The activity of pepsin is but little affected by alcohol in the concentration of 1–2 per cent., it is slightly retarded by 5–10 per cent. and the retardation by concentrations over 10 per cent. is marked. There can, however, rarely be such a concentration present in the stomach of a living man for more than a few seconds.

As regards its action in the small intestine we naturally have less evidence. We can examine its effects upon pancreatic ferments *in vitro* and we find a retardation of the digestion of protein by so little as 2 to 3 per cent. In practice it is probable that alcohol reaches the intestines in such comparatively dilute solution that its action upon pancreatic digestion is of small importance. We can safely say that moderate quantities of alcohol when mixed with other foods have no serious effect upon digestion.

One defence of the use of alcohol is that, by its depressant action on the central nervous system, it may banish the worries that would otherwise reflexly depress secretion and mobility of the stomach, but experiment upon this point is difficult. People who are used to taking alcohol with a meal do not enjoy the meal so much when it is absent and possibly may not secrete so much gastric juice. The teetotaller does not miss it.

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[1] The presence of even 45 per cent. of alcohol does not altogether stop amylolytic action (Roberts). This is confirmed by Aitchison Robertson and by Chittenden and Mendel.

Alcohol, unlike any other fluid or food, is very rapidly absorbed through the walls of the stomach, and while there is no evidence that it carries with it the products of digestion, it can carry substances like chloral and strychnine more rapidly into the blood-stream.

METABOLISM AND ALCOHOL

That alcohol can act as a ***food*** is undoubted, but it acts as a Calorie food only. It cannot take the place of proteins, inorganic elements, or vitamins. In the form in which it is usually taken, beer, wines, or spirits, it contains little or no vitamins, though there is evidence that vitamin B_1 in small amounts is found in some beers (3 units per 100 c.c.).[1] There is so little protective effect in alcoholic beverages that they induce neuritis by decreasing the intake of foods containing vitamin B_1.

Consequently, the consumption of alcoholic beverages can be defended only on the grounds that alcohol can be burnt by the tissues of the body with the production of Calories. It is completely absorbed, partly in the stomach but mainly in the small intestine ; and it is absorbed more rapidly than almost any other food. It reaches its maximum concentration in the blood in from ½ to 2 hours.[2] The concentration in the blood depends upon the concentration in the fluid drunk.

The rapidity with which it enters the bloodstream is greatly decreased by taking it with food, especially with foods containing fat.

One-fiftieth to one-tenth of the alcohol drunk may be excreted in the breath and in the urine. The remainder is metabolized, i.e. burnt to carbon dioxide and water. The rate of combustion is somewhat slow, being about 7 c.c. of absolute alcohol per hour, i.e. the amount found in 100 c.c. of a mild claret. But it can be used to supply energy and to " spare " protein just as carbohydrate can " spare " protein. As it enters the blood so rapidly and as it needs no preparation for combustion, it can conceivably be used in emergencies when it is necessary to give a person, who has exhausted his store of carbohydrates, rapidly available fuel material.

PHARMACOLOGY OF ALCOHOL

Alcohol is usually referred to as a ***stimulant***. This is a misnomer. Throughout the body, particularly in the nervous system, it acts as a depressant. It produces its euphoria by blunting self-criticism. It weakens self-control, dulls sense-perception, and impairs the accuracy of skilled movements. " Under the influence of alcohol, accuracy, avoidance of accident, tactful handling of colleagues and subordinates, observance of discipline, punctuality, reticence in matters of confidence, are all jeopardized. . . ." [1] It is, in fact, a narcotic.

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[1] BOAS-FIXSEN and ROSCOE. (1937), *Nut. Abs. and Rev.*, 7, 823. Riboflavine and nicotinic acid are found in beers.

[2] E. MELLANBY. (1919), *Med. Res. Comm. Spec. Rep.* No. 31.

There is little or no satisfactory evidence that it has any effect on the respiratory system of practical value. In small doses it does not alter the rate of beat of the isolated heart and in large doses it decreases that rate. Its influence on the actual blood pressure is small. It does, however, dilate the superficial blood-vessels and so may as a secondary effect increase the pulse rate.

When alcohol appears to promote recovery from fainting it is probably because strong spirit has been given, resulting in a painful stimulus to the mucous membrane. Painful stimuli, wherever applied—e.g. smelling salts to the nasal mucous membrane—have a similar beneficial effect.

Whenever alcohol has an apparently restorative effect in disease, this is due to localized stimulation or a generalized narcotic and sedative action. To-day there are other more powerful and valuable drugs in the pharmacopæa.

As is well known, its effect in apparently raising the temperature is illusory. It certainly makes a person feel warner, but that is because of the dilatation of the blood-vessels of the skin. The feeling of added warmth is deceptive. What is really happening is that the alcohol increases the loss of heat from the body. People frozen to death have often met that fate through having been drunk when the cold overtook them.

Alcohol in Dietetics

There is little then to be said in favour of alcohol and alcoholic drinks either from the dietetic or medical standpoint. Medical opinion is reflected in the very marked decrease in the use of alcoholic drinks in hospital practice, as is reported elsewhere in this book (pp. 582–4). Dietetics rarely pays them much attention. The utmost that can be said for them is that (1) they have acquired the value of a social gesture of hospitality, (2) they are pleasant drinks to those accustomed to them, and (3) they promote a pleasant euphoria, which, however, is not without its dangers to people with an " escapist " tendency.[2] According to McDougall, alcohol enables the introvert to become extravert.[3] People who are used to alcohol may often be allowed it in their diet when they are on special diets, because they are miserable without it and the misery produces a more deleterious effect than the alcohol.

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[1] *Alcohol: its Action on the Human Organism*, 3rd edn. (1938), 45.

[2] The death rate from alcoholism is only one-eighth of what it was in 1901, and from cirrhosis of the liver only one-fifth. *ibid.*

[3] McDougall. (1944), *An Outline of Abnormal Psychology*, 4th edn.

ALCOHOLIC BEVERAGES

Before proceeding to the study of the alcoholic beverages in detail it may be well to describe the different ways in which the amount of alcohol which they contain may be stated. This is all the more important as an inaccurate use of terms may lead to some confusion.

In this country the standard employed is usually what is known as ***proof spirit***, and an alcoholic liquor is said to be so much above or so much under "proof." Proof spirit is a mixture of alcohol and water, which contains 49·28 per cent. of the former by weight (i.e. 100 grammes contains 49·28 grammes alcohol),[1] and 57·10 per cent. by volume (i.e. 100 c.c. contains 57·10 c.c. alcohol). "The name proof spirit owes its origin to the practice in vogue during last century, of testing the strength of samples of alcohol by pouring them on to gunpowder and applying a light. If the sample contained much water the alcohol burned away, and the water made the powder so damp that it did not ignite ; but if the spirit were strong enough the powder took fire. A sample which just succeeded in igniting the powder was called proof spirit" (Perkin and Kipping). Spirits are described as being ***over proof*** when they are stronger than proof spirit, and ***under proof*** when they are weaker. Thus, 20 over proof means that 100 volumes of the spirit contain as much alcohol as 120 of proof spirit, and 20 under proof means that 100 volumes only contain as much alcohol as 80 of proof spirit.

Instead of using proof spirit as the standard, it is more convenient to speak of the amount of alcohol as being so much *per cent.* The percentage may further be stated either in weight or in volume. Five per cent. of alcohol by weight means, strictly speaking, that 100 grammes of the liquid in question contain 5 grammes of alcohol ; but more usually the expression is used for weight in volume—i.e. 5 grammes of alcohol in 100 c.c. Five per cent. by volume means 5 c.c. in every hundred, and is equivalent to about 4 per cent. by weight.[2] The average percentage of alcohol by volume in some of the commoner alcoholic beverages is roughly as follows:[1]

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[1] 100 grammes of proof spirit has a volume of about 110 c.c., for shrinkage occurs when water and alcohol are mixed.

[2] c.c. alcohol in 100 vols. × 0·8 = grammes in 100 vols.
Grammes alcohol in 100 vols. × 1·25 = c.c. in 100 vols.
" " in 1 litre × 7 = grains per gallon (6 bottles).

SPIRITS:		
Gin, Whisky, Brandy, Rum.	25 under proof	43
	35 ,, ,,	37
WINES:		
Port		20
Sherry		20
Madeira		20
Burgundy		14
Champagne		10
Claret		10
Hock		10
Vermouth		14–20
Empire wines		15–22
British wines		16
CIDER (Bottle)		4·3
BEER (English):		
Ale		3·1–6·6 [2]
Stout		3·9–5·3
Porter		4·0

In France and most other countries the amount of alcohol in wines is estimated by volume and is expressed in "degrees." Thus a wine of 10 degrees strength contains a tenth of its volume of alcohol.

Spirits. Spirits are obtained by the fermentation of various saccharine substances, the alcohol and other volatile bodies produced being separated by distillation. It is this fact of their being the products of distillation which gives to spirits their high alcoholic strength, and distinguishes them from all other alcohol-containing beverages. Almost any substance capable of yielding a fermentable sugar may form the basis of fermentation. Amongst the substances most commonly used in this country are malted and unmalted barley, maize, rice, sugar, and molasses. In some parts of Europe, and especially in Russia, potato starch is largely employed for the purpose. All of these substances yield alcohol on fermentation, but in addition various by-products make their appearance during the process, and it is to the presence of these that the characteristic flavour of the different spirits is due.

Thus, the by-products of the fermentation of malted barley give rise to the flavour of whisky, those of molasses to the flavour of rum, and those of the grape to that of brandy. By means of patent stills the by-products can be almost entirely separated from the alcohol with which they are mixed, and the result is an almost pure form of spirit, the origin of which can scarcely be told, for which reason it is called ***silent spirit.*** By suitable flavouring the clever manufacturer can make this the basis of almost any spirituous drink.

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[1] Quoted from *Alcohol: its Action on the Human Organism.* (1938), H.M.S.O.,

[2] Less in war-time.

Among the by-products of fermentation there are usually found small amounts of alcohols of a higher molecular weight than ethyl alcohol. These are isoamyl, δ-amyl, propyl and isobutyl alcohols, among others, and to a mixture of these the term ***fusel-oil*** is often applied. This fusel-oil is the result of the action of the yeast upon the amino-acids of the substrate upon which it works. If there is much isoleucine in the substances fermented (as, for example, in molasses used in the production of rum), δ-amyl alcohol will be found in the spirit produced; if more leucine than isoleucine, as in a mash of corn and potato, then isoamyl alcohol will predominate in the fusel-oil formed when that mash is fermented.[1] We shall see immediately that fusel-oil and the other by-products met with in spirits have effects on the body in health and disease only second to that of the ethyl alcohol itself.

Whisky has been defined as " a spirit made from malt or malt and grain, and distilled in pot-stills." [2]

It is important to distinguish clearly between genuine " malt whisky," which is made in " pot-stills," and " grain whisky," which is prepared in " patent stills." The bulk of ordinary whisky as it reaches the consumer is probably a blend of these two, grain whisky usually predominating.

(*a*) ***Malt whisky*** is prepared from malted barley which is first carefully dried. In many Highland distilleries peat is used as the fuel for drying, and some of the characteristic flavour of such whisky is believed to be derived from the peat smoke. After being dried, the malt is made into a mash, and here, just as we shall see is true of beer, the nature of the water used seems to have some influence on the character of the final product, soft water giving the best result. The mash is then fermented much as in the making of beer, only the process is allowed to go on longer. When fermentation is complete, the fermented mash or " wash " is distilled in the old-fashioned pot-still. This is the form of still which is by far the most commonly used in Scotch and Irish distilleries. It is made of copper, and the volatile products are condensed in a simple "worm," no attempt being made to separate the spirit from the by-products. The still is heated over an open flame. This is a point of some importance, for it causes some of the sugary substances in the wash to become slightly charred, and there is produced in this way, amongst other things, the substance furfural, the presence of which is one of the chief distinguishing characteristics of pot-still whisky.

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[1] Harden. (1932), *Alcoholic Fermentation*, 176 *et seq.*

[2] The Royal Commission on Whisky and Other Potable Spirits, which reported in 1909, however, concluded that the term " whisky " may legitimately be applied to the product of a patent still also.

The first product of the distillation is called *low wines.* These are redistilled, and yield (1) "fore-shots," (2) "clean spirit," or whisky, (3) "feints"; the residue in the still being the "spent lees."

The fore-shots and feints both contain much of the by-products of fermentation, and are redistilled, the distillate being added to the clean spirit, or whisky.

It must be noted that fusel-oil is not obtained separately by this method of distillation, and the product consists of alcohol plus some of the by-products of fermentation. The whisky thus produced has an alcoholic strength of from 13 degrees to 50 degrees over proof, but before bonding it is usually diluted in Scotland to 11 degrees and in Ireland to 25 degrees over proof.

The by-products—chiefly aldehydes—which it contains give it, when young, a raw, harsh, disagreeable taste, but after keeping for some years in wood it mellows greatly, and the harsher the taste when young, the more full flavoured the whisky when matured.

What the exact nature of the changes is, by which the improvement which whisky undergoes in wood is brought about, we do not yet fully know. This we do know, however, that the percentage of alcohol diminishes; 6 to 8 per cent. of proof spirit being lost by five years' storage. On the other hand, the fusel-oil does *not* undergo diminution, in spite of frequent statements to the contrary.

Irish pot-still whisky differs from Scotch in being prepared usually from a mixture of malted barley with unmalted grain (barley or maize), and the malt is not dried over peat. Otherwise the manufacture of the two is very similar.

(*b*) ***Grain Whisky.*** This is the form of whisky most commonly distilled in England. It is made from a mixture of grains (barley, rye, and maize), with just a sufficiency of malt to convert their starch into sugar. More important than this distinction, however, is the fact that it is distilled by steam and in a patent (Coffey's) still in such a way that the by-products of fermentation (fusel-oil, etc.) are, to a large extent, separated from the ethyl alcohol. The result is that the raw product has much less flavour than young malt whisky, and is sooner ready to go into consumption. When run off the still it is almost colourless and has an alcoholic strength of 60 degrees over proof, but is usually diluted to 11 to 12 degrees over proof before bonding. It acquires a yellowish colour from being stored in old sherry-casks.

As regards the main differences between the two varieties of whisky, it should be stated—

1. That patent-still whisky contains much less of the by-products of fermentation (including fusel-oil) than pot-still whisky, and is therefore much purer.

2. That as a consequence of this, patent-still whisky does not improve nearly so much on keeping as the other variety.

It follows from this that a young patent-still whisky is much better to drink than *young* malt whisky, but that the latter, when fully matured, has a fuller and pleasanter flavour than the former. It is absurd to object to grain whisky on the ground that it contains more fusel-oil than malt whisky, for just the reverse is the truth. After removal from bond, whisky is diluted—or " broken down," as it is termed in the trade—by the addition of water. The legal limit of dilution is 35 degrees under proof (about 37 per cent. alcohol by volume), and most whisky is sold at a strength of about 30 under proof. In other words, we shall not go far wrong if we regard a glass of whisky as containing something between a third and a half of a glass of absolute alcohol. This is not true of war-time whisky, for the statutory dilution was increased.

As already mentioned, most commercial whiskies are blends, and not the product of one distillery. Grain whisky is often used as the basis of the blend, a certain proportion of malt whisky being added to give flavour. Even when the blend contains as much as 90 per cent. of grain whisky, it is often sold as " genuine malt." The public taste now is certainly in favour of a mild-flavoured whisky, hence the large use of grain spirit in blends.

Potheen is the product of illicit stills, and, being usually made from molasses, has the characteristics of rum rather than those of true whisky.

Brandy. If whisky is regarded as distilled beer, brandy may be spoken of as distilled wine.

The best brandy was originally produced in one of the richest wine districts of France (Département de la Charente or Cognac district). The quality varies with the character of the grapes, the best grapes yielding the variety known as Fine or Grande Champagne. This is the only genuine liqueur brandy. The varieties known as Petite Champagne and Première Bois rank next to it. If sold pure, these constitute old Cognac, but a large amount of them is used for blending with inferior varieties.

In a good year six or seven bottles of wine should yield one bottle of brandy. When first distilled the spirit is devoid of colour and of a fiery character. When kept in cask it takes up colour from the wood and gradually becomes mellower. Improvement goes on for a long time, so that the older the brandy the better. After twenty or forty years it contains a considerable proportion of volatile esters and aldehydes, to which it owes its aroma and flavour. French brandies have a 0·02 per cent. of a clear yellow oil with a powerful odour of cognac. It is a natural ingredient and absent from all other types of brandies.[1]

While the above is the origin of genuine brandy, it must be admitted that very little of the brandy sold in this country is so derived. The greater part of it is really concocted in the Cognac district and elsewhere from "silent spirit" coloured with burnt sugar and flavoured with œnanthine or various essences. Such a product is entirely different from genuine brandy, for it contains but little of those volatile esters derived from wine which are so conspicuous in genuine Cognac, and to which it owes most of its attraction.

The production of genuine brandy by the distillation of Spanish wines is now carried on at Jerez and elsewhere. It is also exported by Algiers, Australia, Egypt, and Greece, and some "British Brandy" is manufactured in this country from grain spirit, mixed with argol, French plums, and French wine vinegar, the mixture being subsequently redistilled.

In the United States brandy may be made from cherries, apples, pears, and peaches as well as from grapes.

Rum. Rum is usually produced by the distillation of fermented molasses obtained in the manufacture of raw sugar; the best varieties, however, are obtained by direct fermentation of the juice of the sugar-cane. Pineapples and guavas are sometimes added to the fermented mash to improve the flavour of the distilled spirit. This spirit contains by-products of fermentation, which impart to rum its characteristic flavour. The chief of these is ethyl butyrate, and a considerable proportion of the rum sold in this country is made from silent spirit flavoured with that substance.

Rum owes its dark colour to burnt sugar. When kept for some time, it improves greatly in flavour by the development of esters in which it is peculiarly rich. It usually goes into consumption at about the same alcoholic strength as whisky, or perhaps a little stronger.

Gin (also known as Geneva—from *genièvre*, a juniper—Schiedam and Hollands) is obtained by fermenting a mash of rye and malt, and distilling and redistilling the product. Juniper-berries and a little salt, and sometimes also coriander, cardamoms, and angelica root are added in the final distillation, and the product is run off into underground cisterns lined with white tiles, where the spirit can be kept without colouring. Some is matured in old sherry-casks and becomes as a result straw-coloured.

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[1] VALAER. (1939), *Ind. Eng. Chem.*, **31**, 339; and *Journ. Inst. Brew.*, **45**, 266; quoted in *The Analyst*, **64**, (1939).

The chief seat of the manufacture of genuine gin is at Schiedam in Holland. Much so-called gin, however, is fabricated elsewhere out of silent spirit flavoured with salt, juniper-berries, and turpentine.

Gin is allowed to be sold with as low a proportion of alcohol as 35 under proof (37 per cent. alcohol by volume), but is usually imported at 14 to 15 under proof. Sweetened and diluted gin is sold under the name of ***Old Tom.***

Whilst varying somewhat in alcoholic strength, all the spirits we have been considering agree in containing very little solid matter—less, indeed, than 1 per cent., gin being the poorest in this respect. They have also a very low degree of acidity, rum standing highest, then brandy, with 1 grain per ounce, while whisky and gin have only about 0·2 grain per ounce. They are all practically free from sugar.

The following table, taken from the Report of the *Lancet* Special Analytical Commission on Brandy, represents the comparative composition of the different spirits in a convenient form :

Constituents.	Grain Spirit.	Beet Spirit.	Jamaica Rum.	Scotch Whisky.	Gin.	Typical 3-Star Brandy.
Alcohol per litre by weight in grammes .	932·60	912·90	619·20	436·20	401·50	410·50
Alcohol per litre by volume in c. c. . .	956·00	942·00	695·00	512·00	475·00	485·00
Equal to proof spirit per cent.	167·55	165·09	121·79	89·77	83·26	84·96
Extract per litre . . .	Nil	Nil	6·36	1·16	0·52	6·70
Acidity (calculated as acetic acid) . . .	2·40	4·80	122·40	3·60	19·20	37·50
Aldehydes (as ethylic aldehyde)	1·15	10·92	15·41	14·38	4·72	6·10
Furfural	Nil	Nil	2·08	1·94	0·13	0·82
Alcohol in esters (not in total)	1·84	9·20	161·00	20·24	4·60	27·88
Esters (expressed as ethyl acetate)	3·52	17·60	308·00	38·72	8·80	53·35
Higher alcohols . . .	2·80	6·95	62·58	122·76	13·25	58·48

LIQUEURS AND BITTERS

This group of liquors may be regarded as consisting essentially of spirit sweetened with cane-sugar and flavoured with aromatic or other herbs or essences. It has been well said that they are chiefly the product of the alchemist and the monastery. The proportion of alcohol in them is high, varying from 33 to 50 per cent. or more by volume. The proportion of the other ingredients is shown in the following analyses of some of the most prominent members of the group, taken from König:

PERCENTAGE OF COMPOSITION OF LIQUEURS

	Alcohol.		Extract.	Cane-sugar.	Various extractives.	Mineral matter.
	By vol.	By weight.				
Absinthe	58·93	—	0·18	—	0·32	—
Angostura	49·70	—	5·85	4·16	1·69	0·068
Anisette	42·00	30·7	34·82	34·44	0·38	0·068
Benedictine	52·00	38·5	36·00	32·57	3·43	0·406
Chartreuse	43·18	—	36·11	34·37	1·76	—
Crême de Menthe	48·00	36·5	28·28	27·63	0·65	0·043
Curaçoa	55·00	42·5	28·60	28·50	0·10	0·040
Kümmel	33·90	24·8	32·02	31·18	0·84	0·058

The following is a brief description of the origin and constituents of some of the better-known liqueurs and bitters:

Absinthe. Made by macerating Alpine plants of the wormwood species with the root of anise and sweet-flag and marjoram leaves in 40 per cent. spirit. A glassful (30 c.c.) contains the following amounts of absolute alcohol:

Ordinary absinthe	14·3 c.c.
Demi-fine	15·0 „
Fine	20·4 „
Suisse	24·2 „

The toxic substance is thujone, a ketone isomeric with citral.

Curaçoa. Made in Amsterdam from the rind of bitter oranges grown in the island of Curaçoa.

Kirsch. Made from morello cherries in the Black Forest and containing a small amount of hydrocyanic acid.

Noyau. Made from the *stones* of cherries, containing oil of bitter almonds, and therefore poisonous.

Maraschino. Made by fermenting a small sour cherry (*marasca*) grown in Italy and Dalmatia. Both the cherries and the stones are crushed and 10 per cent. of honey added, and the whole fermented. The spirit is diluted, and kept for some months to mature.

Kümmel. Consists of brandy flavoured with cumin and carraway seeds.

Chartreuse. Originally made at the chief Carthusian monastery, near Grenoble, in France, and also at Florence. It contains a large proportion of sugar, the flavour being derived from various oils contained in angelica, hyssop, nutmeg, peppermint, and other herbs.

Benedictine is a very similar product, made at Fécamp in Normandy.

Angostura is now chiefly made in Trinidad, but formerly at Angostura, the chief flavouring ingredient being the bark of that name, though other species are also added.

Ratafia is a name now applied in France to various liqueurs made from spirit, sugar, and aromatic herbs. It derived its name from the fact that it used to be drunk at the ratification of compacts and bargains.

In practical dietetics the importance of liqueurs is small. Diabetics must take into account their content of sugar. Their use after a meal may be defended on the grounds of their carminative effect.

In studying the ***general action of spirits on the body***, one must distinguish carefully between the action of the alcohol itself and that of the by-products of fermentation which occur along with it. It would be a great mistake to regard spirits as simply mixtures of alcohol and water in nearly equal proportion.

Spirituous liquors are too highly alcoholic for ordinary dietetic use unless taken in great moderation and freely diluted. Two or three glasses of whisky or brandy contain as much alcohol as most people can safely consume in one day. If this limit is observed, however, and the spirit freely diluted, they may do little physical harm.

Why a matured spirit has less deleterious effects than a crude one is still unknown. It was supposed once to be due to the "fusel" oil, the mixture of propyl, amyl, butyl and isobutyl alcohols, in the spirit. They, however, though much more toxic than ethyl alcohol, are not present in sufficient amounts to take effect. Possibly the deleterious substance is furfuraldehyde or pyridine.

MALT LIQUORS

This group includes beer or ale, and porter or stout. There is some confusion in the use of these names, and they have not quite the same meaning in all parts of the country. In some places the term " ale " is applied to the brown beverages, while the black drinks are spoken of as " beers." It is better to regard the terms " ale " and " beer " as synonymous as they were in Anglo-Saxon days, and to apply them to the paler liquors, and to speak of the blacker drinks as " stouts or porters." With the introduction of hops into English brewing, the term " beer " began to mean " hopped malt liquor."

Beer may be defined as the product of the fermentation of malt and hops. We shall see later that much of the " beer " in common use has not, strictly speaking, quite this origin.

Malt is obtained by moistening barley and allowing it to germinate first in heaps and later spread out evenly on a floor of cement or tiles at a moderate and regular temperature. During germination important changes take place : the ferment diastase appears in the grain and acts upon some of the starch, converting it into dextrin and malt-sugar, while part of the proteins, by the action of another ferment, is also converted into soluble forms. The " green malt " so produced is next dried, and, upon the exact temperature at which this is carried out, the character of the beer largely depends, for the lower (within limits) the temperature employed, the more powerful is the action of the ferments contained in the grain, and the larger the amount of soluble substances produced. Low-dried malts produce pale beer ; those dried at a higher temperature yield a darker product.

When drying is complete, the malt is ground and made into a mash with water. The soft water of Dublin in part accounts for the fame of Dublin stout, but the water of Burton-upon-Trent, which contains much calcium sulphate, or permanent hardness, is clearly one of the main causes of the pre-eminence of the pale, strong, and export ales of that town. In some breweries the water is artificially made up to the standard of that locality

After mashing, the wort is strained off from the malt and boiled for an hour or two with ***hops***. Boiling stops any further action of the diastase, and extracts from the hops their soluble ingredients. Chief amongst these are hard and soft resins, tannin, and essential oils. The resins are antiseptic and are necessary in beer for preventing the growth of various moulds, wild yeasts and other micro-organisms. The resins and tannin give hops a bitter flavour. The antiseptic properties of the resins are due to two acids, humulon and lupulon, which are not found in any other plants. The boiled wort is next pumped out and rapidly passed over coolers, and is then ready for the addition of the yeast. Great care is now taken to employ pure yeast for many of the diseases of beer, such as the development in it of acetic acid, are due to contamination with " wild " yeasts. Scientific brewing has made great progress in this direction in recent years. The yeast is added to the wort in vats and fermentation is then allowed to proceed. Here, again, much depends upon the temperature employed. In this country fermentation is usually conducted at rather high temperatures, with the result that most of the sugar is broken up and the resulting beer is rich in alcohol. In Germany low temperatures and " bottom " yeasts are employed, and more sugar and dextrin are left in the beer, but less alcohol is produced. Low-fermentation beers also contain more carbonic acid than most English beers, and are therefore better aerated. It is thus that lager-beer is produced.

When fermentation is complete, the yeast, which has been carried to the surface, is skimmed off. The beer is then run off into casks. Here a secondary fermentation occurs under the action of the small quantity of yeast still contained in the beer, but it is restrained to some extent by the addition to the cask of an extra quantity of hops. The longer this lasts, the greater is the amount of alcohol produced, and if strong beer is desired it must be left in the cask for some months. At the same time some volatile bodies seem to be developed which impart to such beer its full flavour, while the production of more carbonic acid under pressure leads to partial solution of that gas, and gives to the liquor a pleasant sharp taste. Just before bottling, a solution of isinglass in acetic or tartaric acid (" finings ") is added to the cask, which soon settles down in the form of a precipitate, carrying with it any remaining yeast cells and other impurities.

After bottling, the beer becomes brisker than it was in the cask, probably because no gas can now escape from it. Strong beer will keep well in bottle for eighteen months.

The names applied to different beers vary in different breweries, and many of the commercial brands are made by the judicious blending of beers produced in different ways. One can distinguish broadly between ***mild*** and ***bitter ales***, the former containing relatively more malt and less hops than the latter, while in mild the malt is also dried at a higher temperature.

Indian Pale Ale is so called because it was first produced for the Indian market. It is very thoroughly fermented, and contains, therefore, but little sugar, and being highly hopped it has good keeping properties, for the hops act as an antiseptic.

In an ordinary public-house the varieties usually distinguished are "mild ale," which is the poorest; "mild ale and bitter," which is a mixture of these two beers and comes next; and after that "bitter" and "Burton," the last being the strongest of all.

The description of brewing given above applies only to "pure" beers—that is to say, to beverages brewed only from malt and hops. A very large proportion, however, of the beer in ordinary consumption has not this origin, some cheaper source of sugar than malt being employed. Amongst the substitutes so used are invert sugar, potato glucose, flaked maize and rice; and the liquor produced from them is sometimes termed ***substitute beer.***

A large amount of evidence concerning the production of these beers and their effects upon health was given before a Parliamentary Commission some years ago, but it must be admitted that the results were not very definite or satisfactory. It would appear that it takes an expert to tell the origin of a beer from its flavour, and it was certainly not clearly shown that the "substitute" beers are really injurious to health, while they can undoubtedly be produced more cheaply than the genuine article.

Porter and ***stout*** are made in the same way as beer, but the malt is first roasted in cylinders, much as coffee is. This has the effect of producing some caramel, to which the dark colour of these beverages is mainly due, and it must also, by destroying the diastase, prevent the further production of dextrin and sugar in mashing. The proportion of solid matter in the liquor is often enhanced by the artificial addition of caramel or of invert sugar.

German beers, as has been mentioned, are fermented at a lower temperature than those of this country, and contain more dextrins. Secondary fermentation takes place in them to a large extent, and produces much carbonic acid gas. They are decidedly less alcoholic than English beers.

Composition of Malt Liquors

The most important constituents of these beverages are alcohol; dextrins, sugar, and a small amount of soluble nitrogenous matter (together these make up the "extract"); and organic acids.

The table on p. 500[1] gives the approximate composition of some of these beverages.

As might be expected beers contain significant amounts of riboflavine and nicotinic acid[2] and already attention has been called

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[1] McCance and Widdowson. (1942), *op. cit.*

[2] Barton-Wright. (1944), *Biochem. Journ.*, 38, 34.

Composition of Malt Liquors (per pint)

	Alcohol.	Protein.	Fat.	Available Carbohydrate.	Calcium.	Iron.	Phosphorus.	Calories.
	c.c.	g.		g.	mg.	mg.	mg.	
Pale ale, draught	33·7	1·7	Trace	17·9	61	0·28	120	310
Pale ale, bottled	34·5	1·1	,,	16·8	76	0·39	99	308
Mild ale, draught	25·2	2·8	,,	17·4	66	0·28	83	252
Mild ale, bottled	26·8	1·7	,,	20·7	71	0·45	101	273
Strong ale . .	45·0	2·8	,,	27·4	95	0·56	160	428
Stout . . .	26·7	2·2	,,	23·0	58	0·78	130	282
	Beers during war-time were distinctly more dilute.[1]							
Mild . . .	17·3	1·2	0	9·7	57	0·58	—	165
Bitter . . .	24·4	1·2	0	9·7	57	0·58	—	216
Stouts . . .	23·2	2·8	0	19·7	29	0·58	—	256
Strong ales .	32·9	2·8	0	19·7	29	0·58	—	324

to this fact in the House of Commons.[2] Doubtless the brewing industry will focus attention on it in the future. While the riboflavine content is comparable with that of milk the nicotinic acid content is much greater. Even war-time beers gave figures running from 7·8 to 17·0 microgrammes per gramme or about 4·42 to 9·65 milligrammes per pint. Pre-war beers contained more. Thus Worthington Strong Ale, brewed 1798, contained 9·36, Anglo-Bavarian Beer, brewed 1872, 5·84, Reid's Stout, brewed 1899, 9·8, and Combes Export Brown Stout, brewed 1900, 8·68 milligrammes per pint. It is interesting to note that "Chancellor" ale brewed for All Souls College, Oxford, 1938, possessed 25·9 milligrammes per pint, i.e. more than a day's ration.

Action and Uses of Malt Liquors

Action on Digestion. Malt liquors have but little retarding influence on salivary digestion, and what action they do possess is entirely due to their acidity. Stout is twice as acid as beer, and hence has a greater retarding action on the digestion of starch by the saliva.[3] Sound beer, indeed, in some experiments,[4] seemed actually to increase rather than restrain the action of ptyalin *in vitro*, but sour beer has a decidedly retarding effect.[5] On the other hand, in the living body the bitterness of beer may bring about a more profuse flow of saliva, and so end by improving rather than impairing salivary digestion.

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[1] *The Nutritive Values of War-time Foods.* (1945), Medical Research Council.

[2] *Lancet*, (1944), 2, 226.

[3] Chittenden and Mendel.

[4] Aitchison Robertson. (1898), *Journ. Anat. and Physiol.*, 32, 615.

[5] Roberts. *Digestion and Diet*, p. 119.

In the stomach, beer does not remain, if taken alone, any longer than water, for 200 c.c. are found to have completely left it in about one and a half hours. If taken with other food, it delays the chemical processes of digestion more than the mere amount of alcohol which it contains will explain. Some [1] have blamed the "extract" for this, others the salts; [2] but the action is, in any case, not an important one, for even half a litre of beer (about a pint), when taken with a mixed meal, was found to produce but very little delay in the stomach.[3] It is probable, indeed, that a tumblerful of good, brisk beer may actually aid digestion by increasing appetite and calling out a more abundant secretion of gastric juice and more active movements of the stomach. Both stout and beer are frequently prescribed as soporifics.

Influence as Foods. Since malt liquors contain digestible carbohydrates they must be rated as foods. A pint of good ale contains as much carbohydrate as $1\frac{1}{5}$ oz. of bread. It will be seen from the tables that a pint of even war-time beer will give 165 Calories, or about one-twentieth of the total energy required per day.

A glass of milk yields about 184 Calories, a similar glass of good bottled beer about 168. It does not follow from this, however, that beer is almost as good a source of energy as milk, for, as we have seen, alcohol is to be regarded as a food of only limited value. Still less is it as good a food for it lacks any first-class protein and is deficient in calcium, iron, and phosphorus and in most of the vitamins. What energy it provides is purchased at more than twice the cost of that from milk. Whatever may be the grounds for advocating the consumption of beer they can hardly be said to be dietetic or economic.

Malt liquors must be strictly forbidden in many forms of disease. The combined effects of their alcohol and carbohydrates render them specially prone to produce obesity, and they have been regarded as frequent predisposers to gout. In all cases of inflammation of the mucous membrane of the genito-urinary tract, also, they seem, for some reason, to have a peculiarly bad effect, and the recurrence of a gleet, for instance, can often be traced to their use. When taken by diabetics, consideration must be given to the carbohydrate content. Thus a pint of pre-war beer contained 16 to 20 grammes carbohydrate and was equivalent to 1 or $1\frac{1}{3}$ oz. of bread. War beer contains much less carbohydrate and a pint is equivalent to about $\frac{2}{3}$ oz. of bread. Similar considerations apply in the treatment of obesity.

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[1] SIMANOWSKY. (1886), *Arch. f. Hygiene.*, 4, 1.

[2] BUCHNER. (1881), *Deut. Archiv. f. Klin. Med.*, 29 537.

[3] BUCHNER, *op. cit.*

WINES

Wine has been defined as a beverage produced from the juice of the grape by fermentation, and some may prefer to add the saving clause " or with such additions as are believed to improve its keeping qualities." From time immemorial wine has been extolled by poets, æsthetes, gastronomes and others, and it has acquired a mythology, not altogether dead in these more materialistic days. The term has been extended to fermentation products of more humble fruits of the earth than grapes: e.g. apples, pears, cowslip and dandelion blossoms and even the maligned parsnip. The characteristics of all these beverages are a beautiful colour, clarity, high concentration of alcohol when compared with beer, and a pleasant, though acquired, taste.

It must be confessed, however, that the favourite drinks of the northern peoples of Europe are the fiery distillates from fermented grain products and the much less potent ales and beers. Wine is intermediate between spirits and beer in the amount of alcohol it contains. Wine is the normal alcoholic beverage of the countries where viticulture is possible, but in Great Britain the drinking of wine is restricted to the upper classes with the exception, perhaps, of port, which is, or used to be, taken medicinally by the working classes, often under the impression that it is non-alcoholic. Wine achieves a *succès d'estime* in this country and is not the drink of the generality. The attitude of the richer classes may be gauged by the importation of Algerian wine to be sold at the price of 8*s*. 6*d*. a bottle after the Germans were cleared out of North Africa. The dietitian would have preferred, if it had been possible, the importation of olive oil.

Twice within this century the wine-producing countries of Europe, with the exception of Spain and Portugal, have been ravaged by war, and it may be doubted whether in this generation the wine trade can fully recover in France, the valleys of the Moselle and Rhine, Sicily, Italy and Greece.

We propose to cut down the space devoted in previous editions to wine and restrict ourselves to a general statement of the sources, methods of production and analyses of wine.

The quality of wine depends very much upon the variety of the grape, the soil upon which it is grown, the mode in which it is cultivated, and the climatic conditions of particular years. The juice is obtained by crushing the grapes, treading being the method often employed in order to avoid squeezing the stalks and stones too much, and so extracting undesirable ingredients such as tannin.

The chief ***chemical constituents of the juice*** are sugar, nitrogenous matters, tannin, and acids, such as acetic, lactic, malic, and tartaric acids. The sugar is a mixture of grape-sugar, or glucose, and fruit-sugar, or fructose, in the proportion of about three parts of the former to one of the latter.

The relative amount of nitrogenous matter and sugar in the juice has much influence on the character of the wine produced. The yeast lives upon the nitrogenous matter, and splits up the sugar, with the formation of alcohol and other products. If there is but little sugar and much nitrogenous matter present, the yeast can go on growing until all the sugar is split up. The wine will then be "dry" and of an acid taste. Such a wine is hock. If, on the other hand, the sugar is out of all proportion to the nitrogenous substances in the juice, a limit is set to the growth of the yeast and some sugar will be left in the wine, which will then taste sweet. Should, however, the sugar and nitrogenous matter be present in more equal amount, the wine will retain some of both, and, though not sweet, will not have a distinctly acid flavour either, and will be of full "body." It must be remembered, moreover, that no matter how much nitrogenous substance and sugar the juice may contain, the production of alcohol cannot go on indefinitely, for the accumulated alcohol ultimately ends by paralysing the yeast. This takes place when the proportion of alcohol in the fermenting liquid has reached about 16 per cent. by volume. Hence it is that a "natural" wine can never contain more alcohol than this; indeed, there is rarely so much sugar present in the juice as to allow of its containing so much. If a wine contains more than 16 per cent. of alcohol by volume, we may be sure that spirit has been added to it artificially; that is to say, it has been "fortified." Sherry and port as sold in this country are always "fortified" wines; claret and hock, on the other hand, are "natural" wines.

The ***colour*** of red wines is due to a pigment contained in the skins of the grapes, which is turned red by the acids of the juice. As the skins are left in the vat in making such wines, the alcohol which is produced gradually dissolves out this pigment, and so the wine acquires its red or purple tint. The colour of the white or brown wines is mainly due to the oxidation of tannic acid in the cask.

The ***yeast*** which adheres to the skin of the grape, and which is responsible for the fermentation of wine, is different from the yeast which produces the fermentation of malt liquors or spirits. Further, we now know that the characteristic qualities of different wines are due, in some measure at least, to the fact that they are produced by different species of yeasts. Thus, the yeast concerned in producing hock is different from that which produces claret, and by growing a hock yeast on a claret "must," a wine is made which is, as it were, a cross between claret and hock, and has some of the distinctive characters of both. The *rancio* flavour of sherry which is characteristic of it is due to the development of acetaldehyde and derivatives of acetaldehyde by the aerobic film-producing yeasts used in the manufacture of sherry.

The exact details of the process of fermenting grape-juice, in order to produce wine from it, vary considerably in different countries and localities, and little would be gained by attempting to describe them fully. As a rule, the first fermentation lasts for from two to six weeks, depending largely upon temperature, and the wine is left upon the lees till the spring, when it is siphoned off for storage. Prior to being placed in the cask, it is "racked" by the addition of isinglass or white of egg, much as beer is by "finings," in order to remove nitrogenous matters (which prevent the wine from keeping) and suspended impurities. When clear, it is again "racked" off from the deposit, and stored in casks in the cellar.

In the cask many very important changes take place to the occurrence of which the ultimate character of the wine is largely due. For one thing, the alcoholic strength of the wine rises. This is due to the fact that the water of the wine soaks into the wood more than the alcohol does, and is lost by evaporation, so that the wine becomes more concentrated. As the water so lost is replaced by the addition of more wine, the increase in the proportion of alcohol is rendered all the greater. In the cask, too, a partial oxidation of the tannic acid takes place. This causes the white wines to become darker in colour, but has just the reverse effect upon the red wines; for the oxidized tannin unites with, and carries down, some of their pigment.

The small quantity of yeast which always finds its way into the cask produces a slow secondary fermentation of the wine, which often lasts for years. As a result of this, some of the remaining sugar is converted into alcohol, and in this way also the alcoholic strength of the wine is increased. As the proportion of alcohol rises, some of the ingredients of the wine, such as tannin and bitartrate of potash, become less soluble, and fall down in the form of a deposit. During this time also some of the alcohol is oxidized into acetic acid, and the formation of esters takes place. The maximum quantity of these, however, is usually reached in about five years, for the presence of water prevents the formation of esters continuing till all available acids are used up.

After bottling, the formation of esters still goes on, possibly with the aid of micro-organisms, but the alcoholic strength of the wine does not increase. It is quite a mistake to suppose that wine which has been kept long in bottle is necessarily stronger than a younger wine. The reverse is the truth; for the alcohol seems actually to diminish after the wine has been bottled some years. It is also an error to suppose that wine goes on improving indefinitely. Like all other organic things, it is liable to decay by the slow processes of oxidation, and few wines really improve after thirty years; many, indeed, such as clarets, are at their best long before this, and it is only a few of the stronger wines, such as sherry and madeira, which will stand keeping for fifty, or possibly even a hundred years.

Constituents of Wine. The following is a list of the principal constituents found in grape juice, or “must,” and in the wine produced from it.

“Must” contains:

- Water.
- $\left.\begin{array}{l}\text{Glucose}\\ \text{Fructose}\end{array}\right\}$ 10 to 30 per cent.
- Malic and tartaric acids.
- Nitrogenous substances.
- Extractives and essential oils.
- Inorganic material.
- Tannins, colouring matters and fatty substances from the skins and kernels.

Wine contains:

- Water.
- Glucose.
- Fructose.
- Alcohols (mainly ethyl alcohol, but including small amounts of propyl, butyl, amyl, and other higher alcohols). 5 to 22 per cent.
- Acids (mainly tartaric, but also including formic, acetic, propionic, lactic, butyric, malic, and succinic). 0·3 to 0·8 per cent.
- Esters of the foregoing alcohols and acids.
- Aldehydes, such as acetaldehyde and furfuraldehyde.
- Glycerol.
- Nitrogenous substances.
- Extractives and essential oils.
- Inorganic materials. 0·15 to 0·6 per cent.
- Tannins and colouring matter.

It will be realized from this what a very complex fluid wine is.

It would serve no good purpose, however, to give an analysis of wines in detail, for, after all, the information which chemistry can give us about wines is of limited value. It can tell us, it is true, something about those ingredients which have most influence upon health, but it cannot tell much about those volatile compounds to which the most highly-prized qualities of wine, such as flavour and bouquet, are due, and for which one chiefly pays in buying wine when, indeed, one is not merely paying for the label on the bottle.

We propose, therefore, to describe briefly the most important of the constituents which influence health, and afterwards to consider the chief characters of some of the commoner wines in detail.

Alcohols. Wine contains several alcohols, ethyl alcohol, however, being by far the most abundant. Isoamyl, δ-amyl, with still smaller amounts of propyl and isobutyl alcohols, are present in traces, being produced by the action of the yeast on the amino-acids arising from the proteins in the must.[1] A hundred volumes of a natural wine may contain from 6 to 12 grammes of ethyl alcohol. If there is less than this, the wine tastes flat; if there is more, one may be almost certain that alcohol has been added artificially—i.e. that the wine has been "fortified." The advantage of fortifying wine is that it enables it to keep better, subsequent fermentation being restrained, and the production of acetic acid prevented. It is often necessary in the case of wines produced in very warm countries, where fermentation cannot safely be allowed to go on to its full limits, owing to the danger of the growth of "wild" yeasts and the production of acids. Fortified wines not unfrequently have as much as one-third of their volume of spirit added to them, and require to be kept for a long time in bottle, in order to re-acquire a true vinous character. Partial sterilization of the wine by the process of "pasteurization" is now often used to effect the same object as "fortification."

Acids. The natural acids found in wine are tartaric, malic, and lactic. Acetic, formic, succinic, and other acids are produced by fermentation along with carbonic acid.

Tartaric acid is the most important. It occurs, combined with potassium, in the form of bitartrate of potash or argol. As the proportion of alcohol in the wine rises, the bitartrate becomes less soluble, and ultimately much of it falls out in the form of a crust of "tartar." Hence it is that wines become less acid on keeping.

Acetic acid may be produced in wine by the growth in the "must" of special organisms (the "Mycoderma aceti"), which, if unchecked, would ultimately convert all the wine into vinegar. It flourishes especially in very warm countries, and the necessity for preventing its growth is one of the reasons why the wines of such countries are so often fortified.

Acetic acid can also be produced by direct oxidation of the alcohol of wine in the presence of nitrogenous matter, and this occurs to some extent in the cask, and also in bottle, if any air finds its way into the wine through the pores of the cork. In order to prevent this, the bottle should always be laid on its side, so that the cork is kept soaked in wine.

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[1] Felix Ehrlich quoted by Harden. *Alcoholic Fermentation.* (1932), p. 167 *et seq.*

In a sound wine the ***total acidity*** is not more than 0·3 to 0·7 per cent.; above this limit the wine will taste sour. It must be noted, however, that mere taste is no true indication of the acidity of a wine, for the sourness is much concealed by the presence of sugar. As a matter of fact, many sweet wines are nearly as acid as the so-called sour wines.

Dupré found the following amount of acid (reckoned as tartaric) in one bottle of wine:

Claret	4·22	to	5·00	grammes.
Hock	3·70	,,	4·55	,,
Sherry	3·50	,,	3·96	,,
Port	3·18	,,	4·00	,,
Marsala	2·53	,,	2·98	,,

A sample of '47 port analysed by Luff[1] had an acidity of 0·6 per cent., equivalent to 0·39 grammes of tartaric acid in every wineglassful.

The ***volatile acids*** in wine (acetic, etc.) should not be present in a higher ratio than 1 to 3 of fixed acids (tartaric). If the proportion is higher than this, the wine is slightly "turned"—i.e. is on its way to become vinegar. Red wines usually contain rather more volatile acid than white.

Sugar. The chief sugar found in wine is fruit-sugar, or fructose. A "natural" or fully-fermented wine should contain about ½ per cent. of sugar; if there is less than this the flavour is not pleasant. As a rule, therefore, natural wines are "dry." Sauterne is one of the few natural wines which is rather rich in sugar. "Fortified" wines in which fermentation has been checked by the addition of spirit contain 2 per cent. of sugar or more, while the sweet wines may have as much as 20 per cent.

Dupré found the following amount of sugar in different samples of wine:

Hocks . . .	0·091	to	0·56	grammes	per bottle.	
Clarets . .	0·71	,,	1·71	,,	,,	
Sherries . .	14·1	,,	27·3	,,	,,	
Ports . . .	78·6	,,	33·7	,,	,,	
Old marsala .	25·2	,,	29·2	,,	,,	
Sauterne . .	8·1			,,	,,	
Champagne .	32·5			,,	,,	down to almost none.

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[1] *Gout: its Pathology and Treatment.* Cassell and Co. (1898), p. 14.

It will be evident from this that sugar can hardly ever be present in wine to a sufficient extent to be of influence as a *food*. Even a sweet wine with 4 per cent. of sugar will contain only about an ounce in a bottle, or pretty much the same quantity as a bottle of ordinary lemonade. As Anstie points out, it is hardly possible to take in more than ⅓ to ½ oz. of sugar daily in the form of wine without at the same time consuming so much alcohol as would produce intoxication.

Esters. These are produced by the interaction of the alcohols and acids contained in the wine. They are very numerous as regards variety, as can readily be imagined when it is pointed out that a wine containing five different kinds of alcohol and five acids may contain twenty-five esters. Their actual amount, however, is always very small. The highest proportion Dupré found was in a fifty-year-old madeira, and even then there was only 1 part of ester in every 300 of wine.

The esters of wine may be divided into two classes : (1) volatile, (2) fixed. The former are produced by volatile acids, such as acetic ; the latter by the fixed acids, such as tartaric. The volatile esters predominate in natural wines, while most fortified wines contain the fixed esters in greater abundance. To this rule, however, sherry and madeira seem to be exceptions, for they are often rich in the volatile class.

Acetic ester is usually the most abundant volatile ester met with in wine, but old wines may contain traces of propyl, butyl, amyl, caproyl and caprylyl acetic esters as well.

The esters—and especially the volatile ones—are of importance as imparting to wine much of its " bouquet," and a rough estimate of their richness in any particular wine can be made by noting the distance at which the bouquet can be smelt.

Extractives usually make up the bulk of the solid matter in all wines, except such as are rich in sugar. They consist chiefly of pectins and gums. They contribute to the taste and " body " of the wine.

Glycerol is produced along with alcohol in the process of fermentation, and is always present in wine and in sufficient amount to affect the taste. It is usually said that it amounts to one-fourteenth of the volume of the alcohol ; but that is not quite accurate, for different yeasts seem to produce it in varying amount, so that no definite ratio between glycerine and alcohol can be laid down.

Tannin. The tannin in wine is derived chiefly from the skins and stalks of the grapes used and is therefore abundant in red wines. Its nature is specific to wine and the tannin is referred to as œnotannin to distinguish it from the tannins of tea and of oak bark, etc. Tannin in wine decreases by oxidation on keeping and the more mature the wine the less tannin it contains and the less its astringency. A glass of claret has about the same amount of tannin as there is in a cup of tea.

Iron and other Inorganic Substances. As wine has a reputation for blood manufacture it is perhaps reasonable to call attention to its content of iron and copper. There may be as much iron as 2·5 milligrammes per 100 c.c. in both musts and wines, and the normal figure for copper is from 0·25 to 2 milligrammes per litre. Some musts have as much as 23 milligrammes per litre, but they are from grapes which have been sprayed with copper sulphate. When washed these grapes give a must with from 0·8 to 1·8 milligramme copper per litre.

Varieties of Wine. Perhaps the most important division of wines is into (1) natural and (2) fortified. The ***natural wines,*** as already explained, are those in which fermentation has been allowed to go to its full limit—that is to say, until the process is arrested spontaneously either by exhaustion of all the sugar and nitrogenous matter in the grape-juice, or until sufficient alcohol has been produced to prevent the further growth of the yeast. The latter consummation is reached when the fermenting juice contains 16 per cent. of absolute alcohol *by volume.* ***Fortified wines,*** on the other hand, are those in which the process of fermentation has been artificially arrested by the addition of alcohol[1] either as "silent" spirit, brandy, or some other concentrated form. Fermentation being thus arrested before all the sugar has been broken up, such wines are apt to be sweet, and are, of course, of comparatively high alcoholic strength.

Natural wines, on the contrary, are usually poor both in alcohol and sugar. The natural wines also, containing as they do a little acetic acid produced by prolonged fermentation, are rich in volatile esters even in their youth, while the fortified wines, though they may ultimately contain much ester, only arrive at such richness in their old age, and the fixed esters, except in the case of sherry and madeira, preponderate over the volatile.

The principal natural wines are claret, burgundy, "white" wines (e.g. Graves) and hock, and the Hungarian, Italian, Australian, and South African wines. The chief members of the "fortified" group are port, sherry, madeira, and marsala. Greek wines are also usually fortified.

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[1] In the case of some fortified wines, however, e.g., sherry, the alcohol is added after fermentation is complete.

Claret (probably derived from "clairet," a thin "vin ordinaire")[1] is produced in the district of Médoc, the seaport of which is Bordeaux. It is a pure natural wine containing 8 to 13 per cent. of alcohol by volume, very little sugar (about ¼ per cent.), and a moderate amount of acids, acetic acid being always present. It contains also a high proportion of volatile esters. The best growths, or "crus," are Château Margaux, Lafitte, and Latour.

Haut Brion is a red wine produced in the neighbouring district of the Gironde, and resembles a burgundy rather than a médoc. Sauternes are white wines made in the same district, and usually contain a good deal of sugar, from the grapes being allowed to hang for a long time on the vines before they are picked. The famous Château Yquem is the finest of all the white wines so produced.

Burgundy resembles claret, but is richer in extractive matter, and has therefore more "body." It is also of higher alcoholic strength and contains more natural glycerol and less tannin than any other fine red wine. It is produced in the district of that name, the best part being that which stretches between Dijon and Chalon. Beaujolais and Mâcon, though not really produced in Burgundy, are usually classed with those wines. Ordinary burgundy is made from black grapes, but Chablis is a white burgundy produced from white grapes grown in the same district.

Hocks derive their name from Hochheim, on the right bank of the Maine. With the exception of that produced at Assmannshausen, they are all pale wines. They have about the same alcoholic strength as claret, and contain hardly any sugar, for which reason they are apt to seem rather acid. Their acidity, however, is not much higher than that of claret, and they contain almost no acetic acid. They have the advantage of possessing a fine bouquet and extraordinary keeping qualities.

COMPOSITION OF ITALIAN WINES

	Capri (White).	Falerno (White).	Chianti (Red).	Barolo (Red).	Egidio Vitali (Sparkling White).	Valtellina (Red).
Alcohol by weight	11·62	8·64	9·36	10·85	10·08	9·36
,, ,, volume	14·37	10·73	11·61	13·43	12·49	11·61
Tartaric acid .	0·52	0·66	0·60	0·45	0·79	0·41
Acetic ,, .	0·31	0·13	0·18	0·25	0·26	0·29
Sugar . . .	0·76	0·11	0·17	0·18	3·67	0·13

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[1] Everywhere, except in England, claret is known as Bordeaux wine.

Italian wines, both white and red, all belong to the "natural" class. As a rule, they are of low alcoholic strength, but rather more acid and astringent than a light Bordeaux wine. Their acidity is rather high. The analyses[1] given represent the composition of some of the varieties more commonly sold in this country.

Australian wines are full-bodied natural wines, containing rather more alcohol than most clarets. They are chemically pure, and in recent years have improved very much in the finer characteristics of good wine, as the result of greater care in the cultivation of the grape.

The term **sherry** is applied to all the white wines of Spain, being derived from the town of Jerez, which may be regarded as the capital of the sherry-producing district. As drunk in this country, they are all fortified wines, containing from 16 to 22 per cent. of alcohol by volume. A "natural" sherry is quite a possible product, but is never imported into this country on account of its being deficient in "keeping" qualities. Sherries are also all "plastered" wines; that is to say, calcium sulphate is sprinkled on the grapes after they are first trodden, in the proportion usually of 2½ lb. to every ton.

The practice of ***plastering*** is one of great antiquity, and was mentioned long ago by Pliny. It was first adopted, no doubt, empirically, and the advantages of it are still far from being fully understood, although all experienced sherry-growers are of opinion that without its aid the production of a wine having the special characteristics of sherry is impossible. It may be that it acts as a preservative against the "viscosity fungus," which is so much commoner in Southern than Northern wines (Thudichum).

The chief chemical effect of plastering is to decompose the bitartrate of potash in the "must" with the production of insoluble calcium tartrate, potassium sulphate, and tartaric acid, according to the following equation:

$$2KHC_4H_4O_6 + CaSO_4 = K_2SO_4 + CaC_4H_4O_6 + H_2C_4H_4O_6.$$

The phosphates are also thrown down.

As the tartrate of calcium falls out, it clarifies the wine, carrying down with it nitrogenous matters and suspended impurities. The tartaric acid produced renders the wine redder, and increases its free acidity, so facilitating the production of esters later on.

There is introduced into the wine as the result of plastering 0·3 gramme of calcium sulphate per litre, and 1·2 grammes of potassium sulphate, much of it, probably, in the acid form. The potassium sulphate may cause sherry to be slightly laxative to some persons if freely drunk, and renders it also somewhat bitter, but it cannot be said to have any other bad effects. It has been said that it may be productive of cirrhosis,[1] but of this there is no sufficient evidence, and, indeed, the employés in the Spanish bodegas are stated to drink as much as 10½ pints of light sherry daily, without suffering from any injurious effects.

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[1] *Lancet.* (1899), 1, 241.

The amount of sugar in sherry varies from practically nil in the driest sorts up to 4 per cent. in a very raisiny wine. The acidity is lower than that of the natural wines already considered.

Sherry develops in its old age a very large proportion of volatile esters—more, probably, than any other alcoholic liquor, except a genuine cognac.

Broadly speaking, there are two classes of sherries :

1. " Fino," a light, pale, delicate wine of Amontillado [2] or Manzanilla [3] type.

2. " Oloroso," a sweeter, full-bodied, brown wine. Intermediate between these is the class known as " Palo Cortado."

The following is an analysis of examples of these : [4]

Composition of Sherry

	Amontillado. Per Cent.	Oloroso. Per Cent.	Medium. Per Cent.
Solids	2·20	5·45	2·87
Sugar	0·215	1·03	0·65
Potassium bitartrate .	0·08	0·26	0·13
Tartaric acid . .	0·34	0·52	0·41
Acetic . . .	0·12	0·20	0·10
Ash	0·55	0·86	0·70
Potassium sulphate .	0·52	0·76	0·65
Alcohol by weight .	14·82	18·85	15·67
,, ,, volume .	18·25	23·10	19·28
Total esters . .	0·06	0·21	0·075

Pure sherry may be regarded as a genuine grape product, for the substances added to it in manufacture are also derived from grapes. Thus, " grape liquor " is used for sweetening, and the same, slightly caramelized, for colouring. The spirit added in fortification is also obtained by distilling fermented grape-juice. Sherry has the advantage over most wines that it can be drunk all through a meal and also that it does not deteriorate after decanting.

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[1] See later, under cirrhosis.

[2] Amontillado = à la Mantilla (a town near Cordova).

[3] From Manzanilla, a town near Jerez.

[4] *Lancet.* (1898), 2, 1135 (Report of Commission on Sherry, from which many of the statements in the above paragraphs are taken).

Port is the wine produced in the district of the Upper Douro, and takes its name from the town of Oporto. The whole of the wine that reaches this country is fortified, containing from 16 to 22 per cent. of alcohol by volume. One of the chief peculiarities of port is the large amount of " extract " it contains, which gives it a full body. Its acidity is not great, less, indeed, than that of hock, but it contains relatively more acetic than tartaric acid, for the latter is insoluble in the large amount of alcohol which port holds. It possesses a good deal of tannin, the stalks not being removed before fermentation, but this diminishes with age, though when young it is very rough and astringent. It is sweeter than sherry, containing from 2 to 6 per cent. of sugar, for it is fortified before fermentation is complete, not after it, as sherry is. Old port contains a large proportion of esters, but, unlike sherry, contains more fixed esters than volatile. When mellowed it has an excellent flavour and bouquet, and retains only a moderate amount of fruitiness.

Madeira is derived from the island of that name. For a long time the ravages of the phylloxera stopped the production of the wine, but the industry has begun to revive. The wine resembles sherry in its general characteristics and in the high proportion of volatile esters which it contains. It is a fortified wine, containing from 16 to 22 per cent. of alcohol by volume.

Marsala is a Sicilian wine also resembling sherry, but sweeter and containing a much lower proportion of volatile esters. It is only slightly acid.

Greek wines may be either natural or fortified, but usually contain only 10 to 16 per cent. of alcohol by volume. They are rich in volatile acids, and are peculiar, also, in containing some aldehyde. They are often plastered. Their chief defects are due to imperfections in the methods of manufacture.

Champagne is the wine produced in the Champagne district of France, the best varieties being obtained from the prefectures of Rheims and Epernay. It is produced, curiously enough, chiefly from black grapes. These are squeezed in a very powerful press, and the first pressings used to produce the finest wines. The character of the vintage in different years has also a very marked effect on the quality. The expressed juice, or " must," is allowed to stand for 12 hours in order to let all suspended matters fall out, and is then drawn off into casks to undergo the first fermentation. At this stage the different growths, or " crus," are blended to form the special " cuvées," the finest of which are only produced from the best grapes. The young wine is then bottled and left for two years, to undergo the secondary fermentation. The maintenance of a constant temperature is very important at this stage, and is attained at Châlons, Epernay, and Rheims, by storing the bottles in huge cellars excavated from chalk cliffs. During this fermentation a large amount of carbonic acid gas is produced, and as the percentage of alcohol rises a considerable deposit falls down into the neck of the inclined bottle. This is fixed to the cork by freezing, and removed with the latter in the process of "dégorgement." The wine is still of a sour, harsh, or "brut" character, and is made drinkable by "dosage" with liqueur. This consists in adding to it a solution of cane-sugar [1] dissolved in old champagne and good cognac. Upon the amount of dosage the sweetness or dryness of the wine depends. In this country we like champagne dry, and therefore only 2 to 4 per cent. of liqueur is added to the wine exported to England, but in some countries a wine containing as much even as 16 per cent. is preferred. There can be no doubt that the taste for a dry champagne is rewarded by getting a purer wine, for heavy liqueuring covers many defects. Hence the dry wines are really the finest. It must be remembered, however, that unless 8 per cent. of liqueur has been added the quality of the wine will not be found to improve after longer than twenty years.

Champagne should, strictly speaking, be a natural wine, containing from 10 to 13 per cent. of alcohol by volume. The amount of sugar varies from nil up to 14 per cent., depending on the dosage. The acidity is about 0·5 to 0·6 per cent.—i.e. that of an average claret. A *dry* champagne contains about 2 per cent. of solid matter. A bottle of good champagne will contain about five volumes of carbonic acid gas. Four-fifths of this, however, is given off as soon as the cork is drawn.

The table of analyses and Caloric values, given on p. 515, is obtained from Dupré's analyses of wines from a previous edition, by assuming that (i) the alcohol can be completely metabolized, (ii) the sugar is invert sugar and (iii) the contributions of the fixed and volatile acids are negligible.

Similar figures are obtained from making the same calculations of THE HOSPITAL'S *Commission on Light Wines*, 1907, 42, 285.

British Wines. From early times "wines" have been made in this country from various fruits such as apple, pear, cherry, blackberry, and elderberry. Dandelions, cowslips, parsnips, and rhubarb have also figured as the raw material. In recent years, under the fostering influence of the Women's Institutes, there has been a revival in the manufacture on a small scale of these wines. Wine from grapes or grape "must" is also still made in this country.

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[1] The cane-sugar is gradually changed into invert sugar after its addition to the wine.

Wine.	Alcohol. Per Cent.	Sugar. Per Cent.	Calories per 100 cc.	Calories per oz.
Claret	9·68	0·24	69	20
Greek wine	12·35	0·23	87	25
Hock	9·73	0·06	68	19
Hungarian	10·16	0·08	71	20
Madeira	17·82	1·85	132	37
Marsala	16·80	3·50	130	37
Port	18·11	2·54	136	39
Sherry	17·80	3·02	136	39
Champagnes (dry)	10·95	1·77	83	24
,, (sweet)	8·49	5·50	80	23
Clarets	9·04	0·11	67	19
Graves	9·80	0·40	70	20
Haut Graves	9·60	0·27	68	19
Moselles	8·54	0·14	60	17
Sauternes	10·22	0·30	73	21
,, (sweet)	9·34	1·40	71	20

With the introduction of Christianity into Saxon England, production of wine became a necessity owing to its use in the Eucharist, and the cultivation of the grape and the production of wine centred round the monasteries. With the destruction of the monasteries the cultivation of the grape on a wine-making scale died out. An attempt made by the Marquis of Bute, starting in 1877 and ending in 1921, to grow grapes in Great Britain and to make wine from them proved to be uncommercial. Only in the sunniest summers was the wine produced worth drinking.

But wine is still made in this country either from imported Greek grape " must " or from grapes. Sugar is added to the must which is then inverted by boiling and the resulting fluid fermented by imported wine yeast, brewer's yeast or " wild " yeast. When fermentation is over, finings are added, the wine coloured by vegetable dye, and stored in sulphured casks. Ultimately it is bottled.

Other British fermented wines consist of a more or less characterless basis wine made by fermenting raisins, dried currants, or rhubarb or imported grape " must." This is flavoured with ginger, orange peel, lemon peel, concentrated fruit essences, or with imported wine, or " silent spirit."

The alcohol in a basis red wine may run from 6·7 to 11·5 per cent. by weight and the reducing sugars inversely with these figures from 20·6 to 7·9. The same or even greater ranges are met with in the "finished" product. There is little to be said in their favour.

Cider and Perry, derived from the apple and pear respectively, may be conveniently considered here, for they are really to be regarded as wines; cider, indeed, when first made in England in the thirteenth century, was always called "wine."

The finest ***English cider*** is made in Devon, Hereford, Norfolk and Somerset. The mid-season fruit, which ripens in October, is best for the purpose. It is gathered and allowed to mellow under cover for a fortnight, and is then ground to a pulp, the kernels being sometimes left out. The pulp is left in vats for 30 hours, and is then pressed, and 100 gallons of the liquor run into a clean vat and left for some days till it clears. It is then racked, clarified with charcoal and strained through bags, and the clear, bright liquid run into 100-gallon casks and bunged down. Perry is made in a very similar way. If a "sparkling" beverage is desired, fermentation is allowed to go on in bottle. The composition of these beverages seems to vary within rather wide limits. They are only mildly alcoholic, having 3 to 8 per cent. by volume, or much the same proportion as beer. The amount of sugar varies greatly. In a dry cider it may be 1 or 1·5 per cent. or less, but in a sweet cider it may rise to 6 per cent. or more. They are moderately acid (0·1 to 0·6 per cent.), the chief acid present being malic; lactic is also present but, unless sophisticated, cider contains no tartaric acid. The more acid varieties (0·6 per cent.) will have an acidity equal to that of about 1·43 grammes of tartaric acid per tumblerful.

A sample of genuine Devonshire home-made cider which Hutchison examined had the following composition:

Alcohol (by weight) . . .	4·8	per cent.
Solids	1·5	,,
Total acidity	0·66	,,
Volatile acidity	0·089	,,

The following analyses are by Chapman: [1]

	Total Solids.	Alcohol (by Weight).	Calorie Value per Pint.
Bottled cider . .	5·12	3·92	275
Draught cider . .	4·31	3·20	228

The "colic" once associated with cider drinking, now a thing of the past, was due to storage at an early stage of production in leaden receptacles. The colic was a lead colic not a cider colic.

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[1] *Journ. Inst. Brew.* (1932), February, 38, 2.

Medicated wines are compounds, the basis of which is port or sherry, to which has been added extract of beef, extract of malt, peptone, pepsin, coca leaves, cocaine, cinchona, iron, or some other dietetic or medicinal substance. A "beef and malt wine" may usually be regarded as containing about 1½ oz. of extract of meat and 2 oz. of malt extract in a pint of "detannated" port or sherry.[1] For the medicinal wines there is no definite formula. Of the "coca" wines, some are made from coca leaves, others from liquid extract of coca, and some from hydrochlorate of cocaine.

The following table [2] shows the proportions of the chief ingredients present in some of these wines, the composition of the ordinary standard wines being given for comparison.

Wine.	Alcohol by Volume.	Sugar by Weight.	Meat Extract by Weight, corresponding to Nitrogen Found.	Pure Alcohol in a Wine-glassful.
	Per Cent.	Per Cent.	Per Cent.	Fluid Drachms.
Claret	9	0·25	—	1½
Hock	10	Trace	—	1½
Champagne (dry) .	10 to 15	Trace to 2	—	1½ to 2
Sherry (dry) . . .	18	0·2	—	3 to 3½
„ (brown) . .	23	1·0		
Port	20	2 to 6	—	3¼
Wincarnis . . .	19·6	18·2	1·2	3
Glendenning's . .	20·8	10·6	0·4	3⅓
Bivo	19·2	11·5	3·4	3

Such wines are of doubtful value. It is better for an invalid to get beef or malt extract separately and take along with them, if need be, a definite quantity of sound wine of known antecedents.

Medicated wines should in any case only be taken under medical supervision.

Apéritifs are wines containing some bitter ingredient designed to promote appetite and are specially popular in France. The basis of them is either a red wine, as in Dubonnet, Byrrh and Rossi, or a white wine as in French and Italian Vermouth and Cinzano. The bitter constituent in Vermouth is derived partly from wormwood, but other aromatics are present as well, and the alcohol content is about 17 per cent. by volume. Italian Vermouth has some added sugar.

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[1] The quantity of bouillon represented by a wineglassful of such a wine varies from about 4 tablespoonfuls to 1½ teaspoonfuls. (1909), *Brit. Med. Journ.* **1**, 795.

[2] *ibid.*

Apéritifs are comparable to medicated wines; they sometimes fulfil a useful purpose as appetizers.

Cocktails are concoctions of American origin. The basis is usually dry gin (of which they may contain one third of their volume) or sometimes brandy or whisky (e.g. Manhattan Cocktail). To the spirit is added French or (and) Italian Vermouth and, in some cocktails, various bitters (Orange, Angostura, Curaçoa, etc.); in others, flavouring agents such as orange juice (Bronx Cocktail) or lemon. A few drops of Absinthe are sometimes included in the compound. They are usually iced.

Cocktails are intended to serve the same purpose as apéritifs, but being stronger in alcohol (of which they may contain up to 30 per cent.) they have more "kick" in them, and the volatile oils which they contain, especially absinthe, tend to excite the brain. Used in strict moderation they are perhaps harmless enough, but as they are generally taken on an empty stomach they are apt to excite gastritis and being very rapidly absorbed they may easily induce mild intoxication and tend to favour the development of the alcohol habit. They promote appetite by abolishing the psychical inhibitions which interfere with it.

Non-Alcoholic Grape Wines are now made which consist of pure grape juice preserved by pasteurization ("Mostelle," "Vindevie," "Salvator Brand," etc.). Suitably diluted, they form pleasant and refreshing drinks, useful for quenching thirst in fever and possessed of slight laxative and diuretic properties.

Actions and Uses of Wine

General Action. "The conventional value of wine is determined less by its principal ingredients than by the prominence of the specific character termed bouquet and the absence of certain faults." This aphorism of Thudichum, though more than half a century old, sums up the attitude of the modern dietitian to these beverages. Wines have a conventional value and little else. They betoken sociability, hospitality, and generosity. Those accustomed to their use miss them severely when cut off them, even to the upsetting of their digestions, probably via psychological paths. Those unaccustomed to them may or may not obtain a special reaction after taking them. For example, there is an observation vouched for by a Cambridge Blue who is now a physician. In his year there was a teetotaller in the boat who "went stale." His coach ordered him a half-bottle of champagne for dinner which he reluctantly took. The next day he was fit again and never rowed better in his life. It does not follow from this observation that it was alcohol or champagne which caused the change, nor that champagne is good to train on, for it may have been chance, coincidence, or the resolution of a psychological crisis which accounted for the change.

If each constituent be considered in turn it is difficult to see that wines are markedly beneficial or the reverse.

Consider first the ***acids***. These certainly retard the digestion of cooked starch by ptyalin ***in vitro***, because they bring the P_H of the medium below the optimal figure of 6·8. Consequently some have deduced that we should not take acid wines with the sweet courses of a meal, and it is indeed true that we take our hocks, clarets, and burgundies with the earlier and more protein courses, and keep the sweeter wines till the desserts. This neglects the facts (i) that acid-tasting wines often have no more acid than the sweet wines, and (ii) acid wines provoke such a flow of saliva that the end result is probably that the P_H is raised to the optimum figure.

It has been suggested that when wine is drunk the acids may be deleterious in that they neutralize the alkalis of the blood. It must be pointed out that the acids in a litre of wine would hardly neutralize the alkalis of the blood and that when the acid salts of wine are metabolized the organic portion is "blown off" as carbon-dioxide in the breath, leaving an alkaline residue. Liebig long ago pointed out that the free use of hock prevents the precipitation of uric acid in the urine. The same is true of cider and perry. The fact that the consumption of wines and cider renders the urine alkaline would make these substances useful in the treatment of gravel, though, of course, fruits and natural fruit juices would do as well, or better. It is difficult to see how the presence of acid salts in the alcoholic drinks under consideration could be anything but beneficial.

Sugar. It can hardly be that the small amount of sugar taken in wines can have either a beneficial action or the reverse on the normal person. Nor should it affect the dyspeptic. None but the diabetic need take account of the sugar in wine. There is a suspicion that the sweet wines are harmful to the gouty, but that this is more than a suspicion can hardly be maintained.

Tannin. The astringency of wines is due to the tannin which they contain. A rough or astringent wine and an acid wine are by no means the same thing, though often mistaken one for the other. Red wines are richer in tannin than white, young wines than old. Port, especially when young, is the richest of all, and Burgundy, among red wines, is the poorest.

As was said above, the amount of tannin in red wines rarely exceeds that in an equal amount of a well-made cup of tea, so that we cannot imagine that it is either very deleterious to the normal person, useful to the diarrhœic, or harmful to the constipated. Incidentally we may call attention to the tabu against taking tea along with meat and the absence of tabu against the combination of red wine and meat. Lay dietetics is full of such inconsistencies.

Alcohol. We have already discussed the pharmacological effects of alcohol, pointed out that it is a depressant and not a stimulant and that there has been a very marked decrease of the use of alcoholic drinks as medicines in hospital practice. Its value, if used at all, is as a sedative. The effect of any wine in this direction must depend upon its content of alcohol, and as the "natural" wines have only half the alcohol present in fortified wines they presumably are less sedative.

But wines cannot be regarded as mere mixtures of alcohol and water in different proportions. For one thing dilution is of importance. The more dilute the alcohol is, the more slowly it is absorbed and the less chance of an active amount reaching the central nervous system at one moment. Moreover there is a possibility that the esters present in wines influence its pharmacological action. There is a belief widely held that the reason why old wines, and old spirits for that matter, are less harmful than younger and more fiery liquors, is because they contain more of the volatile and fixed esters. The whole subject is obscure and made further obscure by prejudice on the part both of the supporters of and the detractors of the consumption of alcohol.

We think that the following may sum up moderate opinion on the use of wine in health.

1. It is doubtful if the taking of wine can be defended on the grounds that it makes for health. On the other hand there is little evidence that a moderate consumption of wine is deleterious to health.
2. If wines are taken, the light red and white natural wines are the wines for daily use by healthy adults.
3. Half a bottle a day of a natural wine for the sedentary and a bottle a day for the vigorous and actively-employed adult are reasonable allowances.
4. These should be taken at and not apart from meal-times.
5. Fortified wines are best kept for special occasions.
6. There is little evidence that wines are useful in disease.

CHAPTER XVIII

PRINCIPLES OF FEEDING IN INFANCY AND CHILDHOOD

General Observations

Human young take an unconscionably long time to learn to eat without the help and supervision of their elders. Compared with, say, a calf or a lamb, a baby seems incompetent in learning to feed himself and he takes many more months than other animals before he can be left to his own devices in selecting his food. The fact is that a baby, with his potentially large and complicated brain, has to be born in a relatively immature state in order to get born at all. He has in consequence to be protected carefully while his nervous system is reaching the degree of maturity normal to most other mammals at birth. After that he has to be led to take a share in adult food by slow stages. These two periods together occupy the first three years of his life. Thereafter, for a further decade, or more, he is still dependent on others to provide and to prepare his food. This last phase does not concern us here, for, with certain modifications of quantity to allow for growth in addition to maintenance, the diet of the older child does not differ from that of the grown man or woman.

Though the time over which the special problems of infant nutrition apply, lasts for as long as three years, the principles involved are few and simple. Unfortunately they tend to get overlaid by masses of detail. Some examples are necessary, but it is our purpose here to outline principles ; minute instructions of the changes in feeding to be made month by month must be sought elsewhere if, indeed, it is felt that they cannot be filled in by the application of common sense to a few general rules.

Infant feeding may be considered to fall into four stages, though the first cannot claim strictly to come within this title.

I. During intra-uterine life.
II. Suckling (from 0–9 months).
III. Weaning (from 7–12 months).
IV. Transition to adult food (from 1–3 years).

During Intra-uterine Life

Diet during pregnancy has already been discussed (see pages 263 *et seq*). Little need be added to what has already been said despite the fact that we are now considering the nutrition of the fœtus rather than that of the mother. Their two interests are complementary. If the fœtus does not find what he requires for his own growth available from his mother's food, he is uncommonly well adapted to abstract it from her tissues. When, for instance, a pregnant woman's diet does not contain sufficient calcium and phosphorus to form the bones of her unborn baby, these elements are taken from the mother's own skeleton, to her detriment. Other substances, whether simple, such as iron, or complex, such as protein and fat, are similarly filched from the mother's stores if her food does not supply the necessary surplus for her parasitic offspring. To preserve herself from these depredations the pregnant woman must increase her intake of fat, protein, carbohydrate and mineral elements in the way which has already been set out. Recent work in Canada [1] has emphasized and lent precision to this point. In these observations supplements were made to the diets of some of the poorer women in Toronto during the later months of their pregnancies. The remainder were observed as controls. The additional food consisted of one and a half pints of milk, an egg, an ounce of cheese, an orange and some tinned tomatoes daily, together with 2,000 units of vitamin D and some wheat-germ oil. There was a significant difference in the health of those who received the extra food. They were delivered of their babies with less risk and they suffered fewer puerperal complications. Moreover, they produced healthier babies. It seems, therefore, that the fœtus is not a completely successful parasite. Within limits he is nourished at the expense of his mother, but if she can eat and absorb the food needed by both, the resulting baby is better than otherwise would have been the case. Clearly, too, the fœtus cannot take from the mother substances which she does not possess. An anæmic woman is unlikely to provide her baby with an adequate store of iron with which to start life. A healthy woman often cannot, without special food, provide enough for twins. Iron and other blood-forming elements, e.g. ascorbic acid, must be readily available. Similarly, the baby will be born without his proper store of fat-soluble vitamins if these have not been plentiful in the mother's diet. This applies specially to the last few weeks of the pregnancy during the time in which the fœtus is laying down a fairly considerable store of fat under his skin. It seems probable that he combines his reserves of fat with his reserves of vitamins A and D. A premature baby, lacking his subcutaneous fat at birth, is liable to rickets at a much earlier age than a full-term infant. The evidence that vitamin A is stored during the same period is not so complete. There is no doubt, however, of the disadvantages to the baby such as defective teeth, which arise when the mother's food has lacked adequate quantities of vitamin A and D during her pregnancy. Other neo-natal defects can no doubt be traced to shortages in the maternal diet. A deprivation of vitamin K is held by some to be responsible for hæmorrhagic disease in the newly born, and large quantities of this vitamin are therefore given to the mother during the last few days before her delivery. While there is no doubt that a deficiency of prothrombin can on occasion be found in the newly born, it is by no means certain that this explains all the cases of neo-natal hæmorrhagic disease. A more satisfactory method of avoiding prothrombin shortage is to ensure a balanced diet for the mother throughout pregnancy and so avoid the necessity of giving large doses of vitamin K at its end. In general it may be said that diet must be planned to supply both the mother's own needs and the rather special requirements of her prospective baby.

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[1] Ebbs, J. H., Scott, W. A., Tisdall, F. F., Moyle, W., and Bell, M. (1942), *Canad. Med. Ass. Journ.*, **46**, 1; Ebbs, J. H., Brown, G., Tisdall, F. F., Moyle, W., and Bell, M. (1942), *Canad. Med. Ass. Journ.*, **46**, 6.

Suckling

In an ideal world the advice to be given about food during lactation would be essentially the same as that for pregnancy. Unfortunately not all sucklings are nursed at the breast and the subject becomes more complex. Not only is it necessary to consider the food to be eaten and avoided by the nursing mother but the nourishment she gives the baby has also to be analysed in order that it may be imitated in the too frequent cases in which breast feeding is not practised.

There are, then, to be considered here three matters:

(A) The diet of the nursing mother.
(B) The composition of human milk.
(C) Substitutes for human milk.

Diet of the Nursing Mother. If the diet is not sufficient to nourish both a woman and her breast-fed baby, the latter gets all that is available at the expense of the mother. It was observed in the siege of Paris,[1] and the observation has been repeated too often since, that women are able to continue nursing although almost starved to death. Not that this is a state of affairs to be tolerated even from the point of view of the baby. Ebbs[1] has shown clearly how much more likely are women, whose diet is adequate, to carry through breast-feeding than those whose food is insufficient. His observations were made under conditions similar to those quoted on page 522, but on this occasion they were applied to the period after the children were born. The additional food was given to the supplemented group during the first six weeks only of the infant's life. Even so, the difference in the rate of breast-feeding between the two groups at the end of six months was striking ; 24 per cent. of the women on the poor diet were nursing their babies, against the 39 per cent. of the women on the supplemented diet. The discrepancy was greater still the longer the extra food was given, the figures at six weeks being : poor diet 65 per cent., supplemented diet 86 per cent. At six months of age, the babies in the supplemented group were healthier and somewhat heavier than those in the poor diet group.

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[1] 1870.

It should, in theory, be possible to be more precise about the additional needs of a lactating woman than is the case with the diet during pregnancy. The actual amount of milk secreted by her can be measured, its composition is known and in consequence the sum of the daily output as Calories, fat, protein, etc., can be worked out. There is not in fact any great advantage to be gained by a precise mathematical approach. The nursing mother can utilize a wide range of foodstuffs for the secretion of milk ; carbohydrates can be used to build up fats in the milk, and the carbohydrates in the milk have in any case, to be specially elaborated. A woman is much more likely to breast-feed her baby successfully if she is enjoying and digesting food she likes than if she is made to adhere rigidly to some hypothetically correct regimen.

An increased fluid intake is one of the nursing mother's most urgent requirements. It stands to reason that if she is producing up to two pints of milk a day she will need to drink that much more fluid. If she does not do so, she may use some of the water normally excreted by her intestines and become constipated through the decreased bulk of their contents or she may lower her output of milk. Either result is unfortunate, for in the first case she will resort to purgatives which likewise may diminish milk output.

Much of the additional fluid intake may be taken in the form of water. Some, however, should be in the form of milk and of fruit juices. Cow's milk supplies organic ingredients which need little reconstitution to be resecreted as human milk and it is an excellent source of the calcium, magnesium, sodium, potassium, etc., which have similarly to be found. To what limits the milk may be disguised as tea or coffee, or the water disguised as beer, will be the subject of a later paragraph. Juice from oranges, grapefruit or tomatoes will augment her intake of salts and will supply a large part of her requirements of vitamin C.

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[1] EBBS, J. H., and KELLY, H. (1942), *Arch. Dis. Child.*, **17**, 212.

After water, perhaps the most urgent addition to the diet is first-class protein. The daily output of protein in the milk reaches a maximum of over 20 grammes or just under an ounce. The extra intake to provide this must be greater in quantity as there is some wastage in the process of reconstituting the protein to the forms in which it appears in human milk. Cow's milk can supply some of the surplus and the rest should be provided by additional eggs, meat or fish. If cheese is acceptable and readily digested, it can take the place of the extra meat or fish and so give some variety.

No special steps are needed to add carbohydrate or fat as long as the nursing mother can satisfy her hunger with bread and potatoes. The extra milk and the normal amount of butter in her food will supply much of the milk fat and the rest can be elaborated by her own tissues from carbohydrate.

The basic additions to the average adequate diet to be made each day during the period of lactation may therefore be summarized as follows:

One pint of water.
One pint of cow's milk.
Five ounces of fruit juice.
Three ounces of meat or poultry or fish, or two and a quarter ounces of cheese.
One egg.

While it is right to allow a lactating woman to select her diet for herself so long as the foregoing additions are incorporated, care must be taken to ensure that her vitamin intake is adequate. It has been shown [1] that an insufficient amount of vitamin D in the mother's diet, even in a sunny climate, may result in the development of rickets in her breast-fed baby. What is true of one fat-soluble vitamin can certainly be applied to another. The vitamin content of foods tends to vary with many factors. When, as is here the case, it is desirable to make sure of a more than normal intake of vitamins A and D, it is wiser not to rely on foods as a source but to give the vitamins as a supplement. In whatever form they are given, vitamins A and D should exceed each day 4,000 I.U. and 1200 I.U. respectively. The position in regard to water-soluble vitamins is not so clear. Milk is a poor source of ascorbic acid in any case and it is wiser to give the supplement directly to the baby, rather than to hope that a high maternal intake will ensure a sufficient amount in the milk. The mother should be having 50 milligrammes ascorbic acid a day on her own account. If the baby is given his ascorbic acid direct, there is no need materially to increase this amount. Information about the other vitamins in relation to breast milk is mainly of a negative kind. The infants of women, who have a normal balanced diet, are not known to be short of the vitamin B complex while they are at the breast, and it is to be assumed that no additional precautions need be taken in this respect. Conversely, a woman who is herself suffering from deficiency of this or other water-soluble vitamins is unlikely to pass on in her milk a proper amount to her baby.

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[1] Sabri, I. A., and Fikkri, M. M. (1935), *Arch. Dis. Childh.*, **10**, 377.

The inclusion or exclusion of alcohol in the diet of a nursing mother has from time to time been the subject of hot debate often supported by a variety of not very relevant arguments. The fact is that alcohol does not help lactation any more than, in moderation, it hinders it. Baumm and Illner,[1] as long ago as the last century, showed that the daily addition of two or three pints of lager beer to an ordinary diet had no effect on the composition of the milk, and other observers have shown that as much as five glasses of port or champagne are similarly devoid of influence.[2] Physiologically, alcohol may be regarded as the nutritive equivalent of a certain amount of fat, and as fat in the diet is without favourable influence on the composition of the milk, so, too, is alcohol. The common prescription of stout for nursing mothers is thus devoid of scientific justification, for the nutritive ingredients of stout are its alcohol and its dextrins, and both of these are unable to improve the quality of the milk.

On the other hand, the bad effects on the child, which have been attributed to the taking of alcohol by the mother, are equally imaginary; the fear that alcohol will be excreted by the milk being groundless, unless, indeed, the mother indulge in it to the extent of producing intoxication. Distillation of the milk in the above experiments failed to show the presence of any alcohol in it at all.

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[1] (1894), *Samml. Klin. Vorträge (Gynäk)*, N.F., **105**, 41.

[2] Klingemann, quoted by Cautley.

Alcoholic liquors, then, cannot directly affect the quality of the milk. If, however, a little bitter beer or a glass of wine at meals increases the mother's appetite and her power of digesting ordinary food, then such an addition to her diet will improve her own nutrition and with it the amount of her milk.

It has been found,[1] on the other hand, that when coffee is taken by a nursing woman nearly 1 per cent. of the caffeine in the beverage is excreted in the milk and presumably the same would be true of tea. Whether this can have any injurious effect on the infant may, however, be doubted. Besides caffeine, other substances taken by the mother may be excreted in her milk, not always without harm to the baby. This applies particularly to drugs, with which we are not concerned here, though it may be noted in passing that many purgative mixtures contain materials which later give the baby diarrhœa. There are also foodstuffs, such as stewed fresh plums, rhubarb, and boiled new potatoes, which tend to have the same effect on some, but not all, babies. Such articles of diet need not be avoided by a nursing mother unless it is apparent that in the case of her own baby they give rise to undesirable results.

The Composition of Human Milk

A normal, healthy woman provides her baby with milk of the quality and in the quantity he needs for the first seven to nine months of his life. Upon this assumption are based all the deductions which indicate the physiological requirements of a baby during this period. If for any reason it is impossible for the baby to be nursed at the breast, his best chance of survival depends on his being given food which imitates as nearly as possible, both in amount and kind, that with which he would otherwise have been provided. To this end it is necessary to measure the amount of milk taken by healthy babies and to study the composition of the milk. The following paragraphs are concerned with these matters, but first a word of warning is desirable. There are very great variations in individual cases. The figures given are averages. No two babies of the same weight take exactly the same amount of breast milk in a given period, nor does one baby take identical amounts from day to day. There is also a wide range in the composition of human milk; some of the factors concerned in its variability will be referred to later. No amount of averaging will make the quantities set out precisely right for any particular baby and for the same reason there is no purpose in worrying about the last decimal places in analyses of human milk. Much of the work has been repeated in recent years, but unless the newer studies reveal significant differences in the average results, the figures of earlier authorities are just as serviceable and they are in consequence quoted here.

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[1] E. Schilf and R. Wohinz. *Arch. f. Gynäk.* (1928), 134, 201.

Amount of Milk required by the Infant daily. One can arrive only indirectly at the amount of breast-milk which a child should get at each meal and in the course of the day. Arguments from the size of the stomach in infancy are not of much value, for individual variations in the size of the stomach are very wide, and its size after death is no certain criterion of its capacity during life. Nor is the amount of milk in the breast a certain guide, for the child need not exhaust the breast at each meal. A method which has been widely adopted is that of carefully weighing the child before and after each feed. If carried out on a sufficiently large number of infants, this method affords a fairly trustworthy basis from which to arrive at the average quantities required at each age, and it is by such a method that the table on the opposite page has been constructed.

The table includes two sets of observations which were made some time ago and a third series of observations on the early neo-natal period by Mackay [1] which is more recent. This is of interest in that it demonstrates a very close similarity to the earlier figures put forward by Camerer. Mackay in her paper gives her findings as Calories taken each day but supplies the factor for converting these figures into ounces and cubic centimetres in which form, for simplicity, they appear in the table. She also starts her reckoning from midnight of the day of the infant's birth—that is to say, from an average age of twelve hours. In consequence her totals must be placed half-way between the corresponding figures for the early days of life put forward by Camerer. With these adjustments, the two sets of observations, made at some considerable interval apart, are very consistent and tend to confirm the reliability of the other figures of these earlier workers.

Two deductions can be made from this table. First the amount of fluid taken by a healthy infant increases proportionately with his weight during the early months of his life. The average weight of a baby at birth (and for the first week) is about 7 lb. : this is doubled at the age of four months and trebled at a year. He takes, when left to his own devices, between 2 and 2½ oz. of breast milk for each pound of body weight at the age of a week, and a similar amount per pound body weight when he weighs twice as much at the age

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[1] Mackay, H. M. M. (1941), *Arch. Dis. Childh.*, **16**, 166.

AMOUNT OF MILK REQUIRED DAILY

Period.		Author.					
		Camerer.		Mackay.		Feer.	
		Quantity in 24 hours.					
		g.	oz.	c.c.	oz.	g.	oz.
Day :	1st	30	1·1	76	2·7		
	2nd	130	4·2	200	7·0		
	3rd	240	8·6	313	10·5		
	4th	290	10·4	374	13·1		
	5th	330	11·8	416	14·6		
	6th	365	13·0	439	15·4		
	7th	400	14·3	451	15·8	291	10·4
Week :	Mid-2nd	450	16·1	466	16·3		
	2nd	500	17·8			549	14·6
	3rd	497	17·8			590	21·1
	4th	582	20·8			652	23·3
	5th	653	23·3			687	24·5
	6th	734	26·2				
	7th	780	27·9			804	28·7
	8th	803	28·7			804	28·7
	9th	817	29·2			815	29·1
	10th	850	30·3				
	11th	764	27·3				
	12th	767	27·4			828	29·6
	13th	819	29·2			852	30·4
	14th	829	29·6				
	15th	838	29·9				
	16th	843	30·1			893	31·9
	17th	851	30·4			902	32·2
	18th	875	31·3				
	19th	872	31·2				
	20th	820	29·3			947	33·8
	21st	862	30·8			956	34·1
	22nd	848	30·2				
	23rd						
	24th					980	35·0

of four months. Thereafter as his gain in weight slows down, his rate of increased consumption decreases *pari passu.* If the fluid requirements of a baby in the early months of life have to be calculated, it is wise to take the upper limit of normality and give him, daily, 2½ oz. for each pound of body weight. Secondly, the observations set out in the table indicate the Calorie requirements of a healthy baby. Breast milk has a somewhat variable food value with a mean of about 19 Calories to the ounce. For simplicity in reckoning both human and cow's milk are commonly computed to be rather richer than this at 20 Calories to the ounce. Using the simplified factor it will be seen that the healthy infant takes between 40 and 50 Calories for each pound of body weight daily during these early months. When his food has to be prepared artificially it is wiser to accept the higher figure and to offer him 50 Calories a pound a day during the first four months of rapid growth ; the requirements then diminish to 45 and then 40 Calories during the latter part of the suckling period.

Obviously these data must not be applied too rigidly to any given child, for healthy infants of a few weeks may take as much milk as feebler ones whose age is counted by months. On the other hand, wasted infants tend to have a higher rate of metabolism than normal babies of the same age ; they are, as it were, extravagant machines and so may require relatively more food per unit of body-weight than the normal. Hence the rule of feeding an underweight infant according to the expected weight for its age rather than according to its actual weight. Pritchard has also pointed out that the amount of food required by an infant is greatly influenced by such stimuli to metabolism as exposure to air and light.

Analysis of human milk shows that it contains water, protein, a small amount of non-protein nitrogenous substances, fat, carbohydrate, and a variety of mineral elements which are in part linked with the organic constituents and in part in solution. The amount of each of these substances present in different samples of breast milk varies within rather wide limits. Some of the factors contributing to this variation will be mentioned later. It is impossible therefore to give a table of constituents which will be true of every sample of human milk. The average figures, themselves subdivided for the different stages of lactation, set out by Holt, Courtenay and Fales [1] provide as good an account of the composition of human milk as any others. They are as follows :

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[1] Holt, L. E., Courtenay, A. M., and Fales, H. L. (1915), *Am. Journ. Dis. Child.*, **10**, 229.

CONSTITUENTS OF HUMAN MILK
(from Holt, Courtenay and Fales)

	Protein. Per Cent.	Fat. Per Cent.	Carbohydrate. Per Cent.	Mineral Elements. Per Cent.
Colostrum . .	2·25	2·83	7·59	0·3077
Transitional . .	1·56	4·37	7·74	0·2407
Mature . . .	1·15	3·26	7·50	0·2062
Late	1·07	3·16	7·47	0·1978

It has been suggested that the figures for carbohydrate in this table are higher than are commonly found in this country and, for comparison, another series given by Davies[1] is added:

CONSTITUENTS OF HUMAN MILK (from W. L. Davies)

	Protein. Per Cent.	Fat. Per Cent.	Carbohydrate. Per Cent.	Mineral Elements. Per Cent.
Early . .	2·14	3·76	6·29	0·31
Mature .	2·01	3·74	6·37	—
Late . .	1·30	3·30	6·80	0·2

The similarity in these two sets of observations is much more striking than their divergence and the two together can reasonably be taken as representative of the present state of knowledge in this matter.

The ***proteins*** which constitute between them from 1 to 2 per cent. of human milk are lactalbumin, caseinogen and lact-globulin. The last is present in very small amounts except at the very onset of lactation. It has the same qualities as the globulin present in the blood serum and represents such a small fraction of the protein in true milk, as opposed to colostrum, that it can be dismissed from further consideration here.

A knowledge of the relative quantities of the other two proteins, lactalbumin and caseinogen is of some importance, especially when it becomes necessary to adapt cow's milk for the use of young babies. In human milk the lactalbumin accounts for about two thirds of the protein present as the following table shows:

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[1] DAVIES, W. L. (1939), *The Chemistry of Milk*, 2nd edn. London.

DISTRIBUTION OF LACTALBUMIN AND CASEINOGEN IN HUMAN MILK

Source.	Total Protein. Per Cent.	Lactalbumin. Per Cent.	Caseinogen.
Holt, Courtenay and Fales [1]	1·15	0·72	0·43
,, ,, ,, ,,	1·07	0·75	0·32
Plimmer and Lowndes [2]. .	1·00	0·68	0·32

The ratio of lactalbumin to caseinogen of approximately 2 : 1 seems well established and must be regarded as representing the requirements of young babies despite the fact that some analyses of human milk report quantities much nearer equality.

So much for the distribution of proteins in breast milk. In addition, attention should be directed towards the amino-acids from which these proteins are built up. Such knowledge is required for two reasons. First, the amino-acids found to be present are *prima facie* those essential for a baby's proper growth. No prolonged period of feeding with a substitute for human milk can be expected to be successful unless the baby is given, during that time, the amino-acids to which his protein metabolism is adapted. This point has to be borne in mind especially when considering some of the products put on the market for the consumption of ailing infants. Secondly, there is increasing evidence that certain amino-acids are essential for the protection of tissues as well as for their growth. The work on methionine [3] as an agent in minimizing liver damage illustrates this point. (p. 69). A table of the principal amino-acids in human milk compared with those in cow's milk will be found on page 545. It shows that on this particular score cow's milk is a reasonable substitute. The two columns together provide a yardstick against which other reputed infant foods can be measured.

There are other substances in woman's milk besides the proteins which contain nitrogen. This non-protein fraction of the nitrogen is large and represents between a fifth and a quarter of the total nitrogen present in the milk (24·5 per cent. Plimmer and Lowndes,[4] 15–20 per cent. Rietschel.[5]) For the most part, however, it does

[1] HOLT, L. E., COURTENAY, A., and FALES, H. L., *loc. cit.*

[2] PLIMMER, R. H. A., and LOWNDES, J. (1937), *Biochem. Journ.*, **31**, 1751.

[3] HIMSWORTH, H. P., and GLYNN, L. E. (1944), *J. Clin. Invest.*, **5**, 133.

[4] PLIMMER, R. H. A., and LOWNDES, J., *loc. cit.*

[5] RIETSCHEL, H. (1906), *Jahrb. F. Kinderh.*, **64**, 125.

not contribute to the nutritive value of the milk. The bulk of the non-protein nitrogen is present as urea. Some, about one-tenth part according to Courtenay and Brown,[1] appears as free amino-acids. Whatever their significance, these substances containing the non-protein fraction of the nitrogen play no great part in the nourishment of the baby, nor is it necessary to take them into account when a substitute for breast milk has to be found.

The ***fat*** in breast milk is suspended in a fine emulsion. It differs but little, either in quantity or quality, from that found in cow's milk. It accounts for almost half the food value of the milk and, in the various analyses of milk, shows smaller variations than most of the other constituents. The milk in the earlier stages of lactation is slightly richer in fat than that which comes later. Even when the baby is growing most rapidly in the first two months of his life, the proportion of fat in breast milk does not often exceed 4 per cent., a figure which falls later to just under 3½ per cent. when the rate of growth declines. These figures are important and indicate an upper limit of fat requirements. If this is exceeded diarrhœa and vomiting are likely to follow. On the other hand a baby cannot thrive if his food contains materially less fat over a long period.

The full needs of the body for heat will fall upon the combustion of fat and carbohydrate, and as fat is a more compact fuel than carbohydrate and the capacity of the alimentary tract of the young is small, it is to be expected that the percentage of Calories to be obtained from the fat will be high. Moreover, the intensity of metabolism in young growing tissue is some 25–50 per cent. greater than that of adult tissue. This excess production of heat must come from the combustion of fat and carbohydrate. In addition to maintaining the body temperature, fat is used during the period of rapid growth actually as a tissue-producer. The infant lays down fat and substances derived from fat in its fat depots, in the marrow of its bones and in its nervous tissues. Lastly, fat is an essential vehicle of vitamin A, which ensures the health of epithelial tissues and nerves, and of vitamin D, which prevents rickets.

Carbohydrate is present in breast milk as lactose. In addition, there is a variable minute amount of dextrose. The quantity of carbohydrate, 6·5–7·5 per cent., is high compared with the milk of many other mammals. The discordance of the analysis as recorded in this country and in North America has already been referred to on p. 531. As further evidence of the discrepancy Myers[1] found an average of 6·0 per cent. sugar in the milk of 86 women on this side of the Atlantic while Denis and Talbot[2] record 7·1 per cent. as the mean lactose content in 60 samples on the other. The difference is not important. It seems reasonable to assume that British babies will do well with milk containing 6 per cent. of carbohydrate, but that this amount can safely be increased to 7 per cent. Beyond this there is danger. On the whole, carbohydrates are the ingredient of the diet which is least likely to be represented in too small amount. On the contrary, there is a much greater danger of supplying them in excess, or of making them a substitute for fat. An infant who is the victim of such an error may be plump enough, but his muscles are flabby, its skin pale, and its bones often rickety. It is the false appearance of good nutrition which such infants often possess that is apt to deceive the uninitiated, and such children have been known to receive prizes at baby-shows. It must be remembered, too, that carbohydrates, especially when given in excess and in unsuitable forms, are prone to undergo fermentation in the stomach and intestine of the infant, whereby acids and flatulence are produced, causing griping and diarrhœa.

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[1] Courtenay, A. M., and Brown, A. (1930), *Arch. Dis. Childh.*, **5**, 36.

The ***inorganic ingredients*** of breast milk are as important as any of the others. During the early months of life the skeleton is growing at a rate never approached at any later time ; large quantities of calcium and phosphorus are required for this alone. In addition, muscles, blood and nervous tissue, to mention only a few, need salts as well as organic matter for their proper growth. Human milk provides these elements for a baby in the proportions in which they are needed just as cow's milk does for a calf or mare's milk for a foal. The mineral requirements are peculiar to each kind depending on the rate of growth and other factors. Consequently it is important to know what is naturally supplied to a baby so that the same proportions may be imitated as nearly as possible when an artificial substitute has to be provided. The total amount of minerals and mineral salts as represented by the "mineral elements" of breast milk falls between 0·2 and 0·3 gramme per cent. Illustrations of typical findings appear in the following table.

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[1] Myers, B. (1927), *Brit. J. Child. Dis.*, **24**, 249.

[2] Denis, W., and Talbot, F. B. (1919), *Am. J. Dis. Child.*, **18**, 93.

MINERAL CONTENT OF HUMAN MILK

Source.	Mineral Elements. gm. per 100 gm.
Heubner (a)	0·20
Camerer and Söldner (b)	0·27
Holt *et al.* (c)	0·31
,, ,, ,,	0·24
,, ,, ,,	0·21
,, ,, ,,	0·20
Davies (d)	0·31
,,	0·20

Holt, Courtenay and Fales further demonstrate the proportions of calcium, magnesium, etc., which go to make up this inorganic residue.

DISTRIBUTION OF ELEMENTS IN ASH OF HUMAN MILK (grammes per 100 gm.)

Stage of Lactation.	Total Ash Per Cent.	CaO.	MgO.	P_2O_5.	Na_2O.	K_2O.	Cl.
Colostrum	2·83	0·0446	0·0101	0·0410	0·0453	0·0938	0·0568
Transitional	4·37	0·0409	0·0057	0·0404	0·0255	0·0709	0·0588
Mature	3·26	0·0458	0·0074	0·0345	0·0132	0·0609	0·0358
Late	3·16	0·0390	0·0070	0·0304	0·0195	0·0575	0·0575

This table gives a clear indication of the amounts of calcium, phosphorus, potassium and so forth normally afforded to a baby in the first few months of his life. There is more to it, however, than the bare figures suggest. These elements must be offered in a form in which they are available for use. One of the obvious merits of breast milk is that in this they are provided in the right quantities and in a readily assimilable form. When human milk is not given to a young infant it is better to sacrifice an imitation of the precise quantities than to give the right amounts in a form in which they are useless. Fortunately the milk of other mammals,

(a) HEUBNER. (1899), *Zeit. f. Diat. u. Physik. Therapic.*, **3**, 1.

(b) CAMERER, and SÖLDNER. (1896), *Zeit. f. Biolog.*, **33**, 535.

(c) HOLT, E., COURTENAY, A. M., and FALES, H. L., *op. cit.*

(d) DAVIES, W. L., *op. cit.*

although it may contain these inorganic matters in vastly different proportions, does provide them in a form in which they are of use.

No indication has been given in the foregoing table of the iron content of human milk. This is small in any case, about 0·006 gramme per cent. It may be noted that even in this low concentration it is about three times as much as is found in cow's milk. This deficiency can be a fertile source of trouble for those babies who are not fed at the breast.

The importance of ***water*** to the infant will be evident when one recollects that more than three-fourths of the whole body consists of it, and that it constitutes about four-fifths of milk, which is the natural diet of infancy. Water has also local uses in the stomach and bowels, promoting as it does the processes of absorption and secretion. One is too apt to forget that an infant may suffer from thirst as well as from hunger, and that water will allay the former better than milk. The effect of a drink of cold water is certainly always worth trying if a child is suffering from evident but unexplained discomfort.

Variations in the quantity and quality of the milk given by different women are considerable as indeed are they in the milk of the same woman at different times. The figures which have been quoted here are the mean result of many observations and they do not give any idea of the range of findings from which they are derived. It would not be misleading to suggest that this range is 50 per cent. each way on the average recorded. On the whole it is not a serious matter that an average figure is preferred to a range of figures. The most important point that might be made by quoting a wider series of observations would be the adaptability of a baby to different quantities of the constituents of his food. On the other hand mean figures give a much clearer indication of what must be arrived at when substitutes for human milk have to be found and for the most part they have been made use of here.

Many factors share in producing the variations and brief mention must be made of some. The table on p. 529 demonstrates the increase in quantity of the milk and the tables on pp. 531 and 536 the decrease in its quality with the age of the baby. The increase in the quantity corresponds roughly with the baby's increase in weight. As he gets a greater bulk of fluid, the food value of the milk itself per c.c. slowly decreases. The diminution is effected for the most part by a decrease in the fat content ; the carbohydrate and the protein are also involved though to a much smaller degree.

Colostrum (table, p. 531) is the fluid which is secreted by the breasts before they start to elaborate true milk. It is produced for only a very short period from about the second to the fourth day after the birth of the child and its importance in the present context is therefore not great. The composition of colostrum, as will have been observed in the table, differs materially from that of milk. It contains much less fat, but more protein and more inorganic matter. The protein is different in quality from that of milk, for it consists of a higher proportion of globulin. Some authorities attribute considerable importance to the high globulin fraction of colostrum, believing that it conveys from the mother to the baby in the earliest days of his life bodies which give him immunity to certain infections. In humans this function of colostrum is not so great as it is in the case of mammals with a different type of placentation whose young acquire little immunity *in utero*. For the present purposes the short period of secretion of colostrum may be regarded as a preparatory phase both for the baby and for the mother. It is an important stage in itself but, relatively, plays a very small part in the baby's nutrition.

Apart from colostrum, the changes in milk with the progress of lactation present a pattern such as one would expect. When the baby is small he receives little milk of a high food value; as he grows he gets more milk whose concentration slowly diminishes.

The influence of diet on the composition of milk has already been discussed (p. 523 *et seq.*). Little need be added here to the earlier conclusion that while women will continue to lactate even when starving, they can produce milk of the optimum quality only so long as they are properly fed. Conversely, the effect, or rather the almost complete absence of effect, on the milk of over-feeding was demonstrated by Baum and Illner [1] towards the end of the last century. They found a small increase in the fat content when the diet was varied but taken in great abundance and a similar change with a high protein diet. Otherwise their experiments which included starchy, salty and very fluid diets produced no observable change in the milk. This is not to say that a lactating woman can over-eat with impunity. It merely means that she would upset her digestion without in any way enriching her milk.

Seeing that the composition of the milk is so little affected by diet, one should not jump to the conclusion that if an infant is suffering from dyspepsia there is some error in the mother's food. Other causes must be sought and one will almost invariably be found.

Frequency of suckling has some influence on the composition of the milk. The act of suckling serves as a stimulus to the breast, and, if repeated at too short intervals, the richness of the milk is increased. Hence, if a child is crying from indigestion, an attempt to quieten him by frequent giving him the breast leads in the end to the production of a less digestible milk and so to an aggravation of the trouble.

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[1] Baum, R., and Illner. (1894), *Samml. Klin Vorträge*, N.F., **105**, 41.

Variations dependent on individual differences in the mother or her child are of comparatively little importance. It has been found that the milk of any given woman will show greater variations from day to day than the milk of different women on any one day. Weak women, also, seem to furnish as good a milk as those who are robust and strong, and the milk of women who have borne many children is but little poorer than that of those who are nursing their first infant. Age, also, has little influence, for the milk of women approaching the climacteric has not been found inferior to that of mothers hardly out of their teens. Illness, menstruation, pregnancy, fever, and even severe emotional disturbance, are also almost entirely devoid of any appreciable effect on the composition of the milk. The most striking fact about the composition of the milk, indeed, is its independence of outside influences.

Physiological Requirements in the Diet of Infancy

Enough has now been said to allow us to draw some conclusions about the physiological requirements of a young baby. These deductions are aided by the fact that the absorption of the constituents of human milk in the intestine of infants seems to be very complete. Protein [1] is said to be absorbed to the extent of 99 per cent., fat to 97 per cent. and the inorganic materials to 90 per cent., while the sugar enters the blood in its entirety. Consequently one may safely assume that very nearly all the breast milk taken is required and the whole of its constituents take part in the baby's metabolism.

A healthy infant spends most of its time in sleeping and growing. Its muscular efforts are confined to a little sucking, more or less crying and some kicking. From this we might argue that the diet of an infant should contain relatively more of the tissue-builders (proteins and mineral matters) and relatively less of the energy-producers (fats and carbohydrates), than is found in the food of the adult. In point of fact, nature supplies in milk a food of which this is by no means true. If we take the percentage of the total Calories provided by proteins as compared with those provided by fat and carbohydrate together, we find that the figures are almost identically the respective percentages provided by investigations into the diet of families in Great Britain.[1] Caseinogen and lactalbumin supply about 10 per cent. of the total Calories in human milk, and, in the diets of St. Andrews, Cardiff, and Reading, protein supplies 11·0, 10·1 and 10·5 respectively. There is naturally as close an agreement in the sums of the fat + carbohydrate figures. Where the figures are not in agreement is in the percentages of Calories provided by fat and carbohydrate separately. In milk the figures are: fat, 47·5 per cent., carbohydrate 42·1 per cent. In adult (or rather family) diets: St. Andrews, fat, 35·4 per cent., carbohydrate 53·6 per cent.; Cardiff, fat, 33·2 per cent., carbohydrate 56·7 per cent.; Reading, fat, 32·1 per cent. and carbohydrate 57·4 per cent.

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[1] APPLEMAN. (1881), *Deut. Archiv. f. Klin. Med.*, 28, 437.

In other words, the proportion of protein in the infant diet is about the same as that in the adult diet, whereas the fat supplies an even larger percentage of the Calories than it does in the adult.

But we have to remember that all the protein in the infants' diet is first-class protein—protein of high biological value—whereas only a third to a half of the protein in the adult diet is such. This consideration is of fundamental importance in the feeding of infants and children, especially in artificial feeding. It does not matter, therefore, if the percentage of protein is comparatively low, so long as it is protein of high biological value. Further, the protein is mainly used in the construction of new tissues and therefore will not give rise to that production of heat which we have learned to call the specific dynamic action of protein. We thus see that the initial deduction is by no means so contrary to fact as it seems. The infant does actually get more first-class protein in proportion than the adult and needs heat-producing foods to the same proportion as the adult because its metabolism is much more intense and the protein it lays down as tissue has no specific dynamic action.

The constituents of the food of sucklings and adults can be compared in another way. If we choose specific examples, say a four-months-old baby and a ten-stone man doing physical work, we get a set of figures such as those set out in the following table. The baby's weight at four months being 14 lb. or just a tenth that of the man, simplifies the comparison. While the constitution of the man's diet has been selected in an arbitrary way, it is a probable average sample and serves well enough. The figures for the baby are derived from the tables set out earlier in the chapter.

It will be seen that the baby gets nearly twice as much food for each pound of body weight as the adult. The surplus is derived

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[1] St. Andrews. CATHCART and MURRAY. (1931), *Med. Res. Council Report,* No. 151; Cardiff and Reading. (1932), *ibid.*, No. 165.

COMPARISON OF THE CONSTITUENTS OF AN ADULT'S AND A SUCKLING'S FOOD

	Grammes daily.				Excess of baby's over adult's per cent.
	Total.		Per Pound Body Weight.		
	10-st. Adult.	14-lb. Baby.	10-st. Adult.	14-lb. Baby.	
Protein . . .	80	10·35	0·57	0·74	30
Fat	110	29·34	0·79	2·10	166
Carbohydrate .	450	58·50	3·2	4·18	31
Calories . . .	3192	550	22·6	39·3	74·2

largely from fat, and to a much less extent equally from protein and carbohydrate. The difference is even greater than the figures make it appear, for the baby absorbs a higher proportion of his food than the adult ; furthermore, the proteins of his milk are of a greater biological value than those in a mixed diet.

CHAPTER XIX

THE PRINCIPLES OF FEEDING IN INFANCY AND CHILDHOOD (*continued*)

Substitutes for Human Milk

In the last chapter we learnt that the physiological peculiarities of infancy demand that the diet during that period of life should be relatively rich in first-class protein and mineral matter, and especially so in fat. A consideration of the chemical composition of human milk showed how well adapted it is to meet these demands, while a computation of the amount of it which infants consume at different ages enabled us to form some idea of the quantity of each nutritive ingredient actually required at each period of infancy. Further investigation taught us that human milk is easily disposed of by the infant's stomach, is absorbed very completely in the intestine, is a fluid of high nutritive value and therefore eminently adapted for the requirements of the child.

These results of scientific investigation have long been anticipated by experience, and both unite to emphasize the inestimable value to the infant during the first nine months at least of its life of a dietary of human milk. Unfortunately, however, the mother is often unable or unwilling to suckle her infant, and one has to find some substitute for the natural supply. A wet-nurse is, of course, from the infant's point of view, the best alternative, but one need hardly say that this mode of feeding is open to considerable practical disadvantages. The use of preserved human milk is similarly attended with difficulties. When any surplus supply is available, breast milk can be kept for many months either by a process of repeated pasteurization followed by refrigeration or by freezing it speedily on carbon dioxide snow and storing it at a temperature below its freezing point. But the amounts available are meagre and the process so specialized that such preserved human milk can be used only in the direst emergencies. It cannot be looked upon as a practicable alternative means of infant nutrition. The milk of other animals must therefore be considered. The following table exhibits the approximate composition of the milk of some of the commoner domestic animals compared with that of human milk :

COMPOSITION OF THE MILK OF DIFFERENT ANIMALS [1]

	Protein.	Fat.	Lactose.	Ash.
Human	1·3 –2·13	3·30–3·76	6·80–6·29	0·20–0·31
Cow	3·40	3·75	4·75	0·75
Goat	3·67–4·22	4·33–7·57	3·61–4·96	0·84
Mare	1·84–2·05	1·14–1·17	5·77–6·89	0·30–0·36
Ass	1·85–2·04	1·37–1·50	6·09–6·19	0·49

It will be observed that none of these is identical with human milk.

This is not surprising, for the composition of a milk, especially as regards its proteins and mineral constituents, seems to depend upon the rate of growth of the animal for which it is intended. The faster a young animal grows, the richer is the mother's milk in these two ingredients. This fact is brought out very strikingly in the following table : [2]

	Time by which Weight is Doubled.	100 Parts Milk contain			
		Protein.	Mineral elements.	Calcium.	Phosphoric Acid.
Human . .	180 days	1·0	0·2	0·032	0·047
Horse . . .	60 ,,	2·0	0·4	0·124	0·131
Ox . . .	47 ,,	3·5	0·7	0·160	0·197
Goat . . .	19 ,,	4·3	0·8	0·210	0·322
Pig	18 ,,	5·9	—	—	—
Sheep . . .	10 ,,	6·5	0·9	0·272	0·412
Cat	9½ ,,	7·0	1·0	—	—
Dog . . .	8 ,,	7·3	1·3	0·453	0·493
Rabbit . . .	7 ,,	10·4	2·4	0·891	0·996

From time immemorial mankind has tried diverse experiments in the use of milk of other animals as food for their own young. If report be true, Romulus and Remus were by no means alone among the ancients in sucking the dugs of most unlikely foster-mothers. To this day the milk of mares, asses and ewes is a staple part of the food of many races of mankind, and is therefore the first resort for their young as a substitute for breast milk. In this country, however, cow's milk and, to a much smaller extent, goat's milk are normally the only possible alternatives to a baby's proper food. Goat's milk has the same disadvantages as cow's milk only more so, since it is more concentrated than cow's milk, and lacks the merit of being everywhere available. If for any reason it is desirable to use goat's milk rather than cow's milk as a substitute for breast feeding, the same rules for modification apply except that the dilution must be greater in proportion to its higher protein, fat and mineral content. The rest of this chapter is devoted to the adaptation of cow's milk to the use of the very young baby. The fact that this occupies a number of pages should not be regarded as an indication that cow's milk can ever adequately take the place of human milk. There are occasions when its use is inevitable. Death or insanity of the mother are among the few compelling reasons for the cessation of breast feeding. No claim is made that any alternative is so good that its use is warranted as a matter of personal convenience.

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[1] DAVIES. (1939), *The Chemistry of Milk.* Chapman & Hall.

[2] HEUBNER. (1899), *Zeit. f. Diät. und Physik. Therapie*, **3**, 1.

CHEMICAL DIFFERENCES BETWEEN HUMAN AND COW'S MILK

(*a*) **Quantitative Differences.** Taking the average results of a great number of observations on the general chemical composition of the two milks, one may compare them thus:

	Human Milk.	Cow's Milk.
Water . .	87 to 88 per cent.	87 to 88 per cent.
Protein . .	1 „ 2 „	3 „ 4 „
Fat . . .	3 „ 4 „	3½ „ 4½ „
Sugar . .	6 „ 7 „	4 „ 5 „
Mineral salts .	0·1 „ 0·2 „	0·7 „
Reaction . .	Alkaline.	Acid.

One sees that while the total amount of solids in the two kinds of milk is about the same, yet the relative proportions of the different constituents in the two cases are very different. Cow's milk is the richer in protein, mineral matter, and (to a less degree) in fat; human milk excels in sugar. The superiority of cow's milk in the building materials is no doubt due to the more rapid rate of growth of the calf than of the infant, but the excess of carbohydrate in human milk is rather surprising when one compares the relative muscular activities of the calf and the baby. It is difficult to explain this difference save on the grounds of the comparatively greater need of the infant for galactose in building up the central nervous system.

The proportion of lecithin is also relatively much greater in human than in cow's milk, there being 3·05 parts of lecithin to every 100 parts of protein in the former, and only 1·40 to 100 of protein in the latter. This is probably to be attributed to the relatively greater weight of the brain in the child than in the calf.[1]

(*b*) **Qualitative Differences.** On more closely examining cow's milk, one finds that the differences in kind between its principal ingredients and those of human milk are even greater than the differences in the relative amounts. Sugar, indeed, is the only ingredient which is identical in kind in the two milks ; the nitrogenous matters, the fat and the mineral salts must be compared separately in each.

Nitrogenous Matters. We have already seen (p. 530) that human milk includes a considerable proportion of non-protein nitrogen. Cow's milk contains considerably less of these.

The proteins of milk are of three kinds, caseinogen, albumin and globulin. The quantity of globulin in the mature milk both of women and cows is so small that it may be neglected. The proportions of caseinogen and lactalbumin differ with the samples of milk selected but it is constantly found that cow's milk contains relatively much more caseinogen, and human milk more albumin. Davies [2] gives average figures of 2·7 per cent. caseinogen and 0·5 per cent. albumin in cow's milk, that is to say, rather more than five times as much casein as albumin. In human milk (p. 532) we have seen that there is nearly twice as much lactalbumin as caseinogen (0·72 to 0·43 gramme). To put the matter another way, one may say that the caseinogen content of cow's milk is eight times as great, and the lactalbumin content only two-thirds as great as that found in breast milk. It is believed that the food value of caseinogen as a protein is less than that of lactalbumin. If this is true, then cow's milk cannot be considered to have an advantage over breast milk strictly in proportion to its higher protein content. The difference between the two in respect of the biological value of their proteins is, however, insignificant in comparison to the disadvantages presented by the physical properties of caseinogen in excess as a baby's food. Caseinogen behaves in a way entirely different from lactalbumin in the infant's stomach. In the presence of the gastric secretions the proteins of cow's milk form a much tougher clot than those of human milk. Some part of them are wasted because the clot is never broken up completely and part of the protein is excreted unabsorbed in the stools. In addition, the tough clot may, by mechanical irritation, give rise to most undesirable digestive disturbances.

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[1] Burow. "Der Lecithingehalt der Milch und seine Abhängigkeit von relativen Hirngewicht des Säuglings," (1900), *Zeit. f. Physiolog. Chemie.*, **30**, 495.

[2] Davies, W. L., *op. cit.*

Other properties of the proteins of the two milks are beginning to assume increasing significance, namely the relative proportions of the amino-acids from which they are built up. Reference has already been made (pp. 69 and 70) to methionine as a liver-protecting substance. Other amino-acids have also been suggested either as remedies for disorders or as essentials in certain minimum quantities for proper growth and development. Knowledge in these matters is not yet complete. It is desirable, nevertheless, to have in mind the relative proportions of the amino-acids in cow's milk and human milk. The figures given by Plimmer and Lowndes [1] on this subject are set out in the following table:

AMINO-ACID CONTENT OF MILK (grammes per 100 ml.)
(Plimmer and Lowndes)

	Cow's Milk.			Human Milk.		
	Caseinogen 2·28	Lactalbumin 0·71	Total 2·99	Caseinogen 0·32	Lactalbumin 0·68	Total 1·00
Arginine .	0·085	0·028	0·113	0·012	0·034	0·046
Histidine .	0·038	0·013	0·051	0·005	0·011	0·016
Lysine . .	0·140	0·044	0·184	0·017	0·045	0·062
Tryptophane	0·031	0·013	0·044	0·003	0·017	0·020
Tyrosine .	0·132	0·026	0·158	0·017	0·030	0·047
Cystine . .	0·008	0·024	0·032	0·002	0·030	0·032
Methionine	0·066	0·016	0·082	0·009	0·009	0·018

There are surprising variations not only in the total amounts of the amino-acids in the two milks but also in the proportions found in the two caseinogens and lactalbumins. All the amino-acids are represented in both milks and they are, without exception, present in greater quantities in cow's milk. In fact, if milk were diluted with an equal quantity of water, they would still all be present in the resulting mixture in larger amounts than in undiluted breast milk save for cystine alone. It does appear, therefore, that there is a very wide margin of safety in the use of cow's milk, even if diluted, as a source of supply of all the essential amino-acids. Any harm to very young babies is to be expected from their abundance in cow's milk rather than their deficiency.

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[1] PLIMMER, R. H. A., and LOWNDES, J. (1937), *Biochem. Journ.*, **31**, 1757.

Fat. The fat of human milk contains more oleic acid, and has consequently a lower melting-point and is more easily digested than the fat in cow's milk. This greater digestibility of the fat of human milk is increased by the fact that it is present in a much finer state of division than the fat droplets in cow's milk. In practice these differences are not material.

The ***inorganic materials*** in the two forms of milk also show important differences. Not only are calcium and phosphorus both present in much smaller amount in human milk, but there are important differences in the form in which the phosphorus occurs in the two cases.[1] In its high proportion of organic phosphorus human milk recalls the chemical peculiarities of plant embryos or the yolk of egg. Considering the great importance of phosphorus in the nutrition of the infant, and the fact that organic combinations of it may be more easily assimilated than its inorganic salts, one must admit that the differences between human and cow's milk just pointed out are not to be lightly disregarded.

There is, moreover, more iron in human milk than in cow's milk even if the latter does take up some iron from the containers into which it is milked. The lowest figure for iron in human milk is higher than the highest in cow's milk.

In the light of these facts, regarding the profound qualitative differences in chemical composition between human and cow's milk, one must conclude that it is impossible so to modify the latter that it shall be identical with the former. In other words a truly " humanized " cow's milk is a chemical impossibility.

Comparative Digestibility of Cow's and Human Milk

It is a familiar fact that most young infants have much greater difficulty in digesting cow's milk than that of their own mother. Part of the difficulty arises from the difference in the quality of the milks which has been referred to. Indeed, it may be considered that the milk of one kind of mammal can never be wholly suitable for the young of another kind. Yet a minor part of the trouble is of a physical nature in that cow's milk forms a much denser clot in the stomach than human milk.

The greater density of the clot is due—(1) to the absolutely larger proportion of caseinogen in cow's milk, and probably also to those chemical differences between cow's and human caseinogen already mentioned ; (2) to the smaller proportion of fat and soluble albumin relative to the caseinogen which characterizes cow's milk —the soluble albumin and fat of human milk seem to act mechanically in producing a loose clot ; (3) to the fact that cow's milk contains more calcium and acid than human milk, and the density of the clot depends very much on the proportions of these two constituents.

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[1] Hess and Helman, (1925), *J. Biol. Chem.*, **64**, 781, find that the phosphatide content of cow's milk is twice that of human and the total phosphorus four times as great.

For all these reasons cow's milk tends to form a dense, retracted clot in the stomach, while the clot of human milk is loose, friable, and easily broken up.

In the intestine there is much less difference in behaviour between the two milks. The stools of infants fed on cow's milk are richer in mineral matters than those of breast-fed children, but, then, cow's milk is richer in minerals than human. A higher proportion of the fat of cow's milk also escapes digestion than is the case with human milk, and probably also a somewhat greater proportion of protein ; certainly the fæces of bottle-fed babies contain more nitrogen than those of infants reared at the breast.

Infant Feeding with Cow's Milk

It will be agreed, that if a substitute for human milk has to be provided for a young baby, cow's milk or a food derived from cow's milk is the commonest practicable alternative. In the preceding section the differences between human and cow's milk have been considered. Any modification made to the latter to render it suitable for babies must be made with these differences in mind.

Before discussing the means of adapting cow's milk, it is necessary to set down certain general rules that must be fulfilled whatever form of substitute feeding is adopted.

1. The food must be of *sufficient caloric value.* During the first four months of life a baby needs about 50 calories for each pound of body-weight a day. From five to nine months its requirements are less and after the age of nine months these fall below 40 calories a pound body-weight a day. It is necessary, therefore, to know the caloric value of whatever is given. Each ounce of cow's milk gives 20 Calories and an ounce of sugar 116 calories. From these figures the food value of most modifications of cow's milk can be worked out, though when the dried milks are used it is simpler to ascertain their caloric value from the manufacturers. This should be stated on the labels on the tins.

2. Along with its food, a baby must be given *enough fluid.* Observation of breast-fed babies shows that they take about 2½ oz.

of fluid for each pound of body-weight in the day, and this figure should be aimed at when they are "artificially" fed.

3. The *quantity* given *at each feed* must be such that it will satisfy the infant without over-filling his stomach. It is possible to arrive at the quantity of the individual feeds by dividing the baby's total requirements for the day by the number of feeds to be given. The table on p. 529 gives an indication of the daily quantities required at different ages or they can be calculated on the basis set out in the last paragraph. If the baby is fed three-hourly, for the first three months of his life, which is desirable though not always practicable, the total divided by six will give the bulk of the individual feed. In the case of weakly infants it may be advisable to give seven three-hourly feeds, decreasing the amount of each. When feeding is at four-hourly intervals, as should be the case after the third month, the day's total divided by five gives the amount of a single feed.

The principles contained in these first three rules are of general application, but they must not be followed too slavishly. The real test of whether a baby is getting enough is its satisfactory growth and the absence of indigestion. Providing all is well with the infant, slight departures from its theoretical Caloric requirements can be safely neglected. Whatever latitude is allowable in these matters, one thing must not be interfered with, namely the regularity and punctuality of the feeding time. Whether three-hourly intervals are chosen at say 6.0 a.m., 9.0, 12 noon, 3.0 p.m., 6.0 and 10.0 p.m. or four-hourly at 6.0 a.m., 10.0, 2.0 p.m., 6.0 and 10.0 p.m., the baby must be fed at identically the same time each day. Upon this depends to a great extent his chance of good digestion and the success of any form of feeding selected.

4. The method of feeding adopted must be *economically possible.* Those methods which require elaborate apparatus, such as sterilizers and refrigerators, costly proprietary ingredients or great time in preparation, have no place except in the homes of the wealthy.

5. The food offered *must be digestible.* The differences between cow's milk and human milk already enumerated must be minimized.

In modifying cow's milk the factors to be considered are the physical properties of its protein, the relatively greater amount of protein, the relatively smaller amount of sugar and the relatively greater amount of mineral matter, in that order of importance. The greatest drawback of cow's milk as a food for young babies is the way its caseinogen behaves during the course of digestion. Not only is there a large amount of it, but in the baby's stomach it tends to set into a firm, indigestible clot. In theory it should be possible to readjust the total and relative amounts of caseinogen and lactalbumin. Practically, however, it is too tedious to do this as an everyday measure. Consequently it is usual to attack the physical properties of the proteins rather than their proportions so that they form a finer clot in the stomach. According to the way in which this is carried out, other additions may have to be made to the milk in order to maintain the Caloric value.

Methods of Modifying Cow's Milk

(1) ***Heat.*** If milk is boiled for five minutes, the caseinogen undergoes a change which makes it more easily digestible. Some of the protein is lost in the "skin" which forms and the total protein content is thereby slightly diminished. Similar changes can be brought about by heating the milk for a longer period at a lower temperature. In Budin's method of infant feeding the milk is heated for forty minutes at 212° F. The advantages of treating milk by heat are its simplicity, the unaltered food value (any loss of protein is counteracted by a loss of water), and the fact that the milk is rendered sterile. The disadvantages are the change in flavour, the destruction of the antiscorbutic vitamin, and the failure to raise the sugar content or diminish the amount of mineral matter. This method can be used successfully for feeding many healthy babies, providing care is taken to replace the vitamins by other means, e.g. orange-juice and cod-liver oil. For weakly infants it is not the method of choice.

(2) ***Dilution.*** The object here is to reduce the caseinogen and mineral matters in cow's milk, to leave the proportion of fat much as it was, and at the same time to increase the amount of sugar. Taking the average composition of cow's milk and human milk, and adding one part of water to one part of cow's milk, we get the following comparative results:

	Human Milk.	Cow's Milk.	Cow's Milk and Water, equal parts.
Protein . . .	1·5	3·5	1·75
Fat . . .	3·5	4·0	2·0
Sugar . . .	6·5	4·5	2·25
Mineral matter .	0·2	0·7	0·35

This makes the proportion of protein about right but leaves the sugar too low. If now one adds to every 4 oz. of the mixture one medium-sized teaspoonful of milk- or cane-sugar pressed flat and one teaspoonful of 40 per cent. cream, these defects are rectified, and, except for an excess of inorganic substances, the mixture will have approximately the same proportion of each ingredient as human milk.

The proportions of milk, water, sugar, and fat can be altered to suit babies at different ages and in varying states of health. Such variations on the theme of dilution provide the basis of the so-called "formula feeding." Some dairies are prepared to carry out the dilution and reconstruction according to prescription and to deliver the milk ready modified. A similar modification carried out commercially is the "humanized milk." By diluting the milk with an equal quantity of water and subjecting it to the action of a centrifuge, it is divided into two equal parts, one of which contains practically all the fat of the original milk but only half the other ingredients. The deficiency of sugar is remedied by the subsequent addition of that constituent in the necessary proportion. The proportion of protein in such a milk will tend to be too low, and the inorganic substances still too high, but otherwise the composition will correspond pretty closely to that of human milk.

It is clear that all the methods of dilution have one defect; although they bring down the total amount of protein to the level at which it is in human milk, they do not influence in any way the relative proportions of the two kinds of protein—caseinogen and lactalbumin. For this reason the resulting mixtures must remain more difficult of digestion and less useful in metabolism than human milk. Various methods of getting over this difficulty have been proposed by using whey as a diluent, but all such methods are rather troublesome.

(3) ***Acidifying.*** The physical properties of the protein can be modified in some respects by making the milk acid, although the changes brought about are not exactly the same as those produced by heat, peptonizing, or desiccation. The proteins in cow's milk act when in contact with the gastric juice as if they were an alkali, immobilizing some or all of the hydrochloric acid in the juice. The purpose of adding acid before hand is to exhaust this "buffering" action of the proteins. Incidentally the size of the clot formed can be regulated by the manner in which the acid is added to the milk and there are also some more remote effects from the acid milk on the type of bacteria inhabiting the intestine. Of the many possible methods of acidifying milk, two are in common use. In one a measured quantity of milk-souring bacteria is added to the milk which is kept at blood heat in a suitable apparatus (thermos flask or incubator) for twelve hours before use. A small quantity of this soured milk may be used for starting the process in the next lot, though it is well not to carry this process through more than five generations before starting with a new supply of acidifying bacteria (see p. 683).

The second, and perhaps simpler, method is the direct addition of acid to the milk. To each pint of boiled milk, which has been allowed to cool to blood heat (98·4° F.), from 40 to 60 drops of 40 per cent. lactic acid are added drop by drop with constant stirring. In this way a very finely divided clot is formed in the milk which is not rendered unpalatable. Care must be taken not to heat the milk above 40° C. (104° F.) after the acid is added, otherwise a dense curd will form. When milk treated in this way encounters the acid gastric juice the caseinogen, already clotted, cannot form in the stomach the massive curds produced by fresh cow's milk.

(4) ***Citrating.*** The digestibility of the caseinogen can be increased by the addition of citrate of soda in the proportion of 1 grain to every ounce of cow's milk. This is reputed to act, by precipitating the excess of calcium salts, and so causing the caseinogen to set into a less dense curd in the stomach.

In the case of very young or weakly infants, it may be necessary to dilute the milk more freely than in the proportion given above. In such a case a mixture of equal parts of milk, water, and limewater is to be recommended, cream and sugar being added in proportionately larger quantity.

(5) ***Peptonizing.*** It is believed by some authorities that one of the essential differences between the caseinogen of human milk and that of the milk of the cow is that the former is really a stage nearer the digested condition (i.e. peptone) than the latter, and that the greater digestibility of human caseinogen is due to that fact. Whether this be so or not, there can be no doubt that even the partial peptonization of cow's milk renders it much more easy of digestion. Of *complete* peptonization there is no need to speak here. It is of the greatest utility as a temporary expedient in some cases of disease, or in feeble and exhausted babies, but is not really required for healthy infants. Sooner or later the stomach must be educated to deal with pure cow's milk, and the sooner the education is begun the better. Partial peptonization, however, may often be had recourse to with advantage as the first stage in this process of education in the case of infants whose stomachs have a greater difficulty than usual in dealing with cow's caseinogen. It can be conveniently carried out by means of Fairchild's Peptogenic Milk-powder (p. 687). Each measure of the powder contains the ferment required to digest a certain quantity of milk, along with some bicarbonate of soda, which renders the milk slightly alkaline, and enough milk-sugar to raise that ingredient to the proportion found in mother's milk.

By following the directions supplied with the powder, the process of digestion is only carried so far as partially to change the caseinogen of the milk, sufficient to prevent its clotting, but not enough to absolve the stomach from all further labour. Thus, digestion is rendered easy without the stomach's being demoralized. Chittenden[1] analysed the resulting mixture, and compared it with human milk as follows:

	Human Milk.	Milk prepared by Peptogenic Milk-powder.
Specific gravity	1031	1032
Water	86·7	86·0
Protein	2·0	2·09
Fat	4·1	4·38
Sugar	6·9	7·26
Mineral matter	0·2	0·26
Total solids	13·2	13·9
Reaction	Alkaline.	Alkaline.

It will be observed that the two fluids are almost identical in composition. Milk prepared by this method does not clot with rennet, even in the presence of a considerable amount of acid.

(6) ***Condensed Milk.*** Condensed milk is simply cow's milk from which a large proportion of the water has been removed by evaporation under reduced pressure and with the aid of a greater or lesser degree of heat. The milk is reduced to about one third of its original volume. Sometimes whole milk is used for condensing. At others, milk from which some of the cream has been removed is treated in this way, with or without the addition of sugar. There are, therefore, the three following groups:

(*a*) Unsweetened and condensed whole milk.
(*b*) Sweetened and condensed whole milk.
(*c*) Sweetened and condensed skim milk.

(*a*) Of the unsweetened condensed whole milks, often called evaporated milk, the following are examples:[2]

	Total Solids.	Protein.	Fat.	Milk-sugar.
Ideal	38·0	8·3	12·4	16·0
First Swiss	36·7	9·7	10·5	14·2
Viking	34·2	9·0	10·0	13·3
Hollandia	43·0	11·3	9·8	18·5
Libby's Evaporated Milk	31·0	10·0	9·4	11·7

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[1] (1896), *New York Medical Journal*, **54**, 71.

[2] Most of the analyses of condensed milks in this chapter are taken from Pearmain and Moor's *Analysis of Food and Drugs*, Part I, pp. 69-78.

Carnation milk is an unsweetened evaporated milk in which 60 per cent. of the water has been removed. It is homogenized to break up the fat globules so as to make them resemble in size those of human milk and is finally sterilized.

If 1 part of such a milk is diluted with 2 parts of water, the resulting fluid corresponds more or less closely to a good sample of pure cow's milk.

(*b*) The sweetened condensed whole milks contain, as a rule, rather more added cane-sugar than there are solids in the milk. The following is the composition of some of the best brands; they are arranged, again, according to their richness in fat:

	Total Solids.	Protein.	Fat.	Milk-sugar.	Cane-sugar.
Nestlé .	77·2	9·7	13·7	15·0	37·2
Rose . .	76·6	8·3	12·4	17·6	36·1
Milkmaid .	76·3	9·7	11·0	14·6	38·7
Full Weight	76·5	12·3	11·0	13·5	37·2
Anglo-Swiss	74·4	8·8	10·8	16·0	37·1

There are many other brands in the market besides these, but none of them is superior to the above.

Now, although the members of this group contain as much fat as the unsweetened condensed milks, yet so much sugar has been added that if they are mixed with only as much water as has been removed in condensation, the resulting fluid would be so sweet that one could hardly drink it. Hence, a degree of dilution is recommended on the tins of these brands which renders it impossible for the resulting fluid to be at all like cow's milk in its proportion of protein and fat.

(*c*) Of the condensed separated (or skim) milks there are an immense number in the shops. They resemble in composition the second group just described, except in that they contain almost no fat (always less than 2 per cent.). When diluted in the proportions recommended for infants, the resulting fluid is very poor in protein and almost free from fat, *and is therefore entirely unsuited for a baby's nourishment.*

It should be noted that the composition of all forms of condensed milk varies considerably, owing to differences in richness of the original milk, and to variations in the degree of condensation and in the amount of sugar which has been added. This is borne out by the following table from a Report by Dr. Coutts to the Local Government Board,[1] which is based upon a large number of analyses taken from various sources:

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[1] *An Inquiry as to Condensed Milks, with Special Reference to their Use as Infants' Foods,* 1911.

VARIATIONS IN CHEMICAL COMPOSITION OF CERTAIN CLASSES OF CONDENSED MILK

	Full Cream.				Machine-skimmed Sweetened.	
	Sweetened.		Unsweetened.			
	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.
Total solids per cent.	68·1	83·6	29·2	38·0	56·9	79·1
Fat ,,	8·0	13·7	8·2	11·9	0·1	6·5
Protein ,,	7·3	11·4	8·0	10·0	7·6	12·3
Mineral elements	1·6	3·4	1·6	2·5	1·6	2·9
Lactose ,,	11·6	17·6	11·1	16·0	10·9	17·0
Cane-sugar ,,	36·1	44·6	Nil	Nil	30·4	52·6

DIGESTIBILITY OF CONDENSED MILK

There is no doubt that condensed milk is more easily digested than fresh cow's milk. When diluted in such proportion as to restore them to the condition of ordinary cow's milk, the condensed milks either do not clot with rennet at all, or the resulting curd is much looser than in the case of pure cow's milk.[1] The presence of acid does not affect the result. The explanation of these facts probably is that the caseinogen undergoes some chemical change in the process of condensation which renders it incapable of forming a dense clot. Certainly this greater digestibility is one point in favour of condensed milk, and justifies its occasional use for infants who are entirely unable to digest ordinary cow's milk, even when specially modified.[2]

NUTRITIVE VALUE OF CONDENSED MILK

The chief defect of condensed milks from a nutritive point of view is that they are apt to contain too little fat. The unsweetened milks are alone satisfactory in this respect. The skim milks are absolutely to be condemned on that account, and even the sweetened whole milks, though they contain all the fat of the original milk, yet require so great a degree of dilution, owing to the amount of sugar which they contain, that the product is notably deficient in fat. "The following table shows the character of the liquid—it cannot be called milk—that is produced by following out the directions on the labels of half a dozen of the best brands of (sweetened) wholecream milk" (Pearmain and Moor):

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[1] The experiments were performed with the First Swiss brand and with Nestlé's.

[2] The great degree of dilution in which condensed milk is usually given no doubt also explains in part the ease with which babies digest it.

Sweetened Whole Milk.	Dilution recommended for Household Purposes.	Fat in such Product.	Dilution recommended for Infants' Use.	Fat in such Product.
A . . .	1 to 3	2·6 per cent.	1 to 5	1·8 per cent.
B . . .	1 " 5	1·6 "	1 " 14	0·7 "
C . . .	1 " 5	1·6 "	1 " 14	0·6 "
D . . .	1 " 6	1·4 "	1 " 15	0·7 "
E . . .	1 " 5	2·1 "	1 " 14	0·8 "
F . . .	1 " 5	1·7 "	1 " 14	0·7 "
G . . .	1 " 5	1·7 "	1 " 14	0·7 "
Human milk	—	—	—	3·5 "

There can be no doubt that an immense amount of harm is done to infants by the indiscriminate use of such milks. Babies fed on them may look fat enough, but they are pale and flabby, and often suffer from rickets, for fatness produced by abundance of sugar in the milk is, as has been already pointed out, by no means a sure indication of health, and the pictures of such fat but flabby infants so freely spread abroad by the makers of condensed milks are very deceptive.

If a sweetened condensed milk is used at all, it should only be for a short period (not beyond the first three or four months), and the deficiency of fat should be made good by the addition to the diet of cream or cod-liver oil. Babies of delicate digestion often do well for a time on Nestlé's milk in the proportion of two teaspoonfuls to six tablespoonfuls of water. Such a mixture contains 1·13 per cent. of protein, 1·28 per cent. of fat, and 6·72 per cent. of sugar, and by the addition of one teaspoonful of centrifugal cream to each feed the fat is brought up to 3 per cent. The caseinogen in this mixture, being very dilute, is easily digested, and the relative excess of sugar does no harm if such a method of feeding is not continued beyond the fourth month.

The only kind of condensed milk which can be unreservedly recommended, however, is that made from whole cow's milk without the addition of sugar. If 1 part of such a preparation is diluted with 2 parts of water, the product may be regarded as identical with good cow's milk, and will therefore require further dilution, sweetening, and addition of cream, just as fresh milk does

(p. 549). Used in this way, condensed milk is convenient in cases in which fresh milk is for any reason unobtainable, or for temporary use in the case of infants who are unable to digest the latter.

The question whether condensed milks are to be regarded as sterile or not is one of some importance. Delépine found that the degree of heat to which they are subjected during condensation is not necessarily sufficient to kill all disease germs.[1] On the other hand, Derning and Davis [2] conclude that evaporated milk may be regarded as for all practical purposes sterile.

Some forms of condensed milk such as the whole-cream evaporated milk are particularly adapted for irradiation by ultra-violet light. When this is done, as in the case of Carnation brand milk, the vitamin D content is enhanced to such a degree that not only is rickets prevented, but it may actually be cured. If the condensed milk has not been irradiated, a daily ration of cod-liver oil is necessary. With any form of milk so treated, additional vitamin C in the form of orange, tomato, black currant, rose hip or swede juice must be given. As a source of calcium and phosphorus condensed milk is quite satisfactory.

(7) ***Dried Milk.*** The water in milk can be removed and the solid part left as a powder. This occupies about an eighth of the space of the original fluid, so that if one part of the powder is added to eight of water, the milk is reformed with the fat, protein, and carbohydrates in their original proportions. In the course of drying, especially if this be done by the roller process, the physical properties of the proteins are changed ; when the reconstituted milk enters the stomach, the curd formed is more finely divided and more digestible than that of fresh cow's milk. This constitutes the chief claim of dried milk as a substitute feeding for young babies. In addition, it is free from dangerous organisms easily handled and contains all the vitamins of fresh milk except the vitamin C. Many manufacturers add vitamins to the milk powder, so that in use it has actually a higher proportion of accessory food substances than fresh unheated cow's milk.

The varieties of dried milk have become rather confusing, for beside the powder from whole cow's milk and milk from which half or all the fat has been removed, there are available the dried form of many modifications of cow's milk. These modified dried milks have a vast range of compositions. They may be grouped very roughly as follows:

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[1] See *Report to the Local Government Board upon the Effects of Certain Condensing and Drying Processes used in the Preservation of Milk upon its Bacterial Contents*, by Dr. S. Delépine (Food Reports, No. 21), 1914.

[2] (1931), *Archives of Pediatrics*, 48, 42.

(*a*) With added sugar, with or without the removal of some of the fat.
(*b*) With the proportions of the proteins altered more or less to resemble those of human milk.
(*c*) With the total protein either increased or decreased above that normally present in cow's milk.
(*d*) With the addition of acid, with or without the removal of some of the fat.
(*e*) With the addition of substances such as iron, to combine feeding with therapy.
(*f*) With the addition of more complicated carbohydrates than sugar.

The graduation from the simpler to the more complex milk powders could be continued into another group of dried foods. The latter for the most part consists of sugars, dextrins, and more or less modified starches, which in use have to be added to cow's milk. They include, also, foods derived from dried vegetables. This group is of more service at the time of weaning than as a substitute for human milk in early infancy. In the next Chapter representative examples of the simpler, as well as the more complex, foods are set out. In choosing a dried milk for a young baby it is well to avoid those which contain unmodified starch, for up to the age of six months a baby has little power to break down starch to sugar. In general, it is perhaps best to choose a simple dried milk and to add to it such extra sugar as may be thought necessary. Many of the milk powders containing added substances such as iron, almost cease to be foods and become food and medicine; their use needs medical supervision.

From what has been set out above it is clear that there are several ways of providing a substitute for human milk. From the fact that there are so many one may safely conclude that no one of them is ideal. They should be used only under the pressure of necessity. The home conditions of the baby and the amount of time and money that can be spent in preparing his food, will play a part in deciding the most suitable form to use in each instance. The substitute for human milk may be expected to give him a reasonable chance of survival, but it must be remembered that it remains at best a poor second to his natural food. For a baby less than seven months old, human milk must be the only desirable food. Quite apart from its quality as the one really digestible food, it has other advantages. Among these may be mentioned its cheapness, accessibility and sterility. No other food can be found which can be "kept on tap" so near the baby and which needs so little preparation to ensure its freedom from infection.

CHAPTER XX

THE PRINCIPLES OF FEEDING IN INFANCY AND CHILDHOOD (*continued*): PROPRIETARY FOODS FOR INFANTS: FEEDING OF OLDER CHILDREN

There are many proprietary foods for infants available on the market.[1] The list which follows is not exhaustive; it may serve to illustrate the variety which exists in their composition. The values given in the table refer to the proportions of water, protein, fat, and inorganic substances in the dry powder before it has been prepared for use. They are the figures supplied by the manufacturers. Care is taken that a product does not depart significantly in its analysis from the figures supplied. From time to time, however, different producers decide deliberately to alter the composition of a food. It is advisable, therefore, to enquire before a food is chosen whether any such modification has recently taken place. The composition of the food should be clearly stated on the label.

The foods fall into two main groups: the first those which are to be made up with water before use, and the second those intended to be added to milk. Generally speaking the former are mixed with water in the proportion of one part of food powder to eight of water. This does not always apply, and the directions of the manufacturer should be consulted about the quantity of water to be used. The object aimed at with many of the modified dried milks is to provide, when they are made up, a fluid whose composition closely resembles that of human milk. Clearly, therefore, the proper dilution with water is as important as the preparation of the powder.

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[1] When this edition was revised (1945) many of these products were not readily available owing to the exigencies of war. They have, nevertheless, been included, for they or their successors will again become of practical importance. In the meanwhile many firms have "pooled" their dried milk as National dried milk. The composition of this latter, whether full cream, half-cream or skimmed (household), corresponds very closely with that of similar status among the proprietory kinds.

TABLE SHOWING THE COMPOSITION OF INFANT FOODS

Food.	Water.	Protein.	Fat.	Carbohydrate.	Inorganic Salts.	General Description and Remarks.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	
Dried human milk . .	—	12·8	29·9	55·6	1·7	A standard of composition with which artificial substances may be compared.
GROUP I (1)						
Ambrosia, Full Cream. .	1·91	26·72	28·00	37·85	5·52	Full-cream dried milk.
Cow and Gate, Full Cream	2·5	26·6	27·3	37·6	6·0	,, ,, ,,
Dorsella, Full Cream . .	2·7	27·2	26·2	37·1	6·0	,, ,, ,,
Ostermilk No. 2 . . .	2·9	24·9	26·5	38·5	5·6	,, ,, ,,
(2)						
Cow and Gate, Special Half Cream	2·5	30·3	16·5	43·8	6·9	Unmodified half-cream dried milk.
(2*a*)						
Ambrosia, Half Cream .	2	20·5	15·0	57·50	5·0	Half-cream dried milk with added sugar.
Allenbury's, Half-Cream Food	2·4	12	9	72·6	—	With modified protein, malted extract of wheat, and diminished fat.
Cow and Gate, Half Cream	2·5	20·0	15·0	58·0	4·5	Half-cream dried milk with added sugar.
Ostermilk No. 1 . . .	2·0	17·0	20·0	56·0	3·9	Dried milk with diminished fat and modified protein.
Sprulac	3·0	32·5	10·5	46·5	7·5	Diminished fat and increased protein.
Casumen Milk Protein Food	6·5	38·1	10·7	41·1	3·6	Dried milk with added protein and carbohydrate.

(3)						
Cow and Gate, Separated	3·0	35·5	0·8	52·8	7·9	Dried skimmed milk.
(3*a*)						
Secway	—	13·0	1·0	76·0	9·0	Dried whey.
Allenbury's Sweet Whey .	—	13·2	1·2	75·0	—	,, ,,
(3*b*)						
Casumen	4·50	89·2	2·4	—	3·90	Milk protein.
Protosol	—	91·5	1·9	—	—	,, ,,
(4)						
Allenbury's No. 1 . . .	2·5	10·8	18·5	63·4	4·1	Dried milk from which some casein has been removed and dextrin-maltose added.
Allenbury's No. 2 . . .	2·6	11·6	17·5	63·8	3·9	Similar, but with more protein and with malted extract of wheat.
Cow and Gate, Humanized	2·0	15·5	26·5	52·5	3·5	Dried milk, with modified protein and added sugar.
Humanized Dorsella . .	2·9	12·38	25·93	55·62	2·9	Similar.
Humanized Ambrosia . .	2·9	16·4	20·0	57·6	4·0	,,
Humanized Trufood . .	1·0	11·95	29·3	52·25	5·2	Dried milk with modified caseinogen—lactalbumin ratio and with added sugar.
Geego Full Cream . . .	3·0	17	17	58·0	4	Milk dried *in vacuo* by special process with added sugar.
,, Half Cream . .	3·0	19	10	62·0	4·5	Similar, with less fat.
,, Separated . .	3·0	22	0·12	69·0	5	Similar, with fat removed.
Neave's Milk Food . .	2·4	20·0	26·0	47·1	4·5	A mixture of dried milk, lactose, and maltose.

TABLE SHOWING THE COMPOSITION OF INFANT FOODS—*continued*

Food.	Water.	Protein.	Fat.	Carbo-hydrate.	Inorganic Salts.	General Description and Remarks.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	
(4*a*)						
Almata	—	12·5	25·0	56·6	2·6	A dried food derived from egg yolk, casein, butter and malto-dextrin of a composition similar to breast-milk.
Veguva No. 1	1·2	16·0	15·0	65·0	2·8	Dried cow's milk to which a mixture of specially prepared carbohydrates has been added, also sodium caseinate, egg yolk, yeast, and the juices of carrot and tomato.
(5)						
Lacidac, Full Cream . .	2·5	25·5	26·5	36·0	6·0	Dried full-cream milk with added lactic acid 3·5% of powder.
,, Half Cream . .	2·5	29·0	16·0	42·5	6·5	Similar, with less fat.
,, Separated . .	3·0	34·0	0·7	51·3	7·5	Similar, without fat.
Allergilac	3·0	25·8	18·0	43·5	7·0	Dried milk with diminished (1·0%) lactalbumin and 2·7% (in powder) lactic acid.
Prolac	2·55	40·0	19·5	29·5	6·5	Dried bacterially-soured milk.
Beurlac	3·0	31·0	9·0	46·5	7·5	Similar, with less fat and more sugar.
Mead Johnson Protein Milk	—	39·0	26·5	24·0	—	

(6)						
Ambrosia with added iron	1·91	26·72	28·00	37·85	5·52	Full-cream dried milk to which iron is added as iron and ammonium citrate in two strengths, either 31½ or 60 grains to the pound of the powder.
Dorsella, with added iron	2·7	27·2	26·2	37·1	6·0	Similar, with 31½ grains of iron and ammonium citrate to the pound of the powder.
Ferrolac, Full Cream . .	2·8	24·9	26·5	38·5	5·8	Full-cream dried milk with a "therapeutic" amount of iron added.
Ferrolac, fat modified .	2·0	17·0	20·0	56·0	4·1	Similar, with diminished fat and added sugar.
Hemolac	2·45	26·50	27·20	37·50	5·90	Full-cream dried milk with 31½ grains of iron and ammonium citrate to each pound of the powder.
GROUP II (1)						
Benger's Food	5·3	12·2	0·9	80·3	1·0	When mixed with milk as directed all but 0·5% of the carbohydrate becomes soluble. At the same time the casein is modified by the trypsin present in the powder.
Modilac	2·0	18·6	19·0	56·3	4·1	A dried milk with added cane-sugar and dextrin to be mixed with water.
Peptolac	3·0	33·4	7·3	49·7	6·6	Similar, with added protein and starch-splitting ferments.
Mellin's Food	6·3	7·9	Trace	82·0	3·8	A completely malted food with all the carbohydrates in a soluble form. May be regarded as a dried malt extract.

TABLE SHOWING THE COMPOSITION OF INFANT FOODS—*continued*

Food.	Water.	Protein	Fat.	Carbo-hydrate.	Inorganic Salts.	General Description and Remarks.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	
Cheltine Maltose Food	4·6	5·3	0·27	87·6	2·25	A fully malted food containing no starch. To be used with milk.
Horlick's Malted Milk	3·7	13·8	9·0	70·8	2·70	A mixture of dried milk (50%), barley malt (23%), and bicarbonate of soda (0·75%). Contains no unaltered starch when mixed.
Moseley's Food	10·5	11·0	0·92	76·4	0·94	Complete conversion of all starch occurs during mixing. To be used with milk.
(2)						
Allenbury's Malted Food No. 3	4·65	9·45	1·06	82·64	2·2	Roasted flour with added malt. Prepared by diluting with milk and water.
Cow and Gate Malted Milk	2·0	7·2	8·0	79·3	3·5	A dried milk with added carbohydrate which is mostly soluble on the addition of water.
Savory & Moore's Food	4·5	10·3	1·4	83·2	0·6	Composed of wheat flour with the addition of malt. When prepared according to the directions, most but not all of the starch is converted to soluble forms (chiefly dextrins).
(3)						
Cerex	4·0	11·3	1·5	82·7	0·5	Prepared from malted wheat flour. Starch partly converted.
Allenbury's Cereal	2·0	13·5	5·8	75·2	4·5	Half the carbohydrate is soluble.

Farex	6·5	18·0	2·5	72·0	4·0	Pre-cooked mixed cereal food.
Robinson's Patent Groats	5·5	12·5	7·3	73·0	1·7	Ground, prepared oat flour.
Robinson's Patent Barley	—	11·0	1·33	78·44	0·86	Ground, prepared barley flour.
Veguva No. 2	5·85	2·72	0·62	89·6	1·2	Dried finely divided spinach, carrot and tomato, combined with prepared carbohydrates, egg yolk and yeast.
Ridge's Food	7·9	9·2	1·0	81·2	0·70	A baked flour, containing only 3% of *soluble* carbohydrates, the remainder being starch. Recommended to be made with milk or water. Made with water alone is totally insufficient food.
Neave's Food	6·5	10·5	1·0	80·4	1·60	Resembles the above, but recommended to be made with milk and water.
Sister Laura's Food	6·8	9·9	0·8	81·0	1·10	A starchy food intended as an addition to undiluted milk.
Miriam's Food	8·2	13·5	4·8	71·7	1·6	Prepared from a mixture of several cereals.
Bananina	9·5	4·1	0·4	84·0	2·07	A highly starched food prepared from banana flour.
Chapman's Whole Flour	8·4	9·4	2·0	79·3	0·90	A finely ground whole-wheat flour. Not much superior in nutritive value to ordinary "households" flour. Starch entirely unaltered.
Scott's Midlothian Oat Food	10·2	10·7	6·2	70·0	2·7	A fine oat flour. Somewhat inferior in nutritive value to "groats." Starch unaltered. Fibre 0·2%, some iron phosphorous and calcium added.

The range of preparations in the first group is considerable and it is not easy to place them in any logical order. One clear-cut subdivision are those powders obtained by drying down unmodified milk and associated with them the dried skimmed and partly skimmed milks. Thereafter the changes become difficult to classify. Increased carbohydrate, readjusted protein, diminished fat, all have their part either separately or in various combinations. The acidified dried milks form another subdivision, as do the milks to which iron or other inorganic substances, such as calcium, have been added.

To add to the variations is the fact that commonly two processes, the "roller" and the "spray," are in use for drying milk. The proteins of the milk behave rather differently in the stomach according to which process has been used. In the case of dried unmodified milk the roller process has the advantage that the curd formed by the reconstituted milk is finely divided and soft, while the spray dried milk gives a curd almost as dense as that of fresh cow's milk. When the proteins of the milk have been readjusted to resemble those of human milk before the milk is dried, the differences resulting from the two methods of drying are less noticeable, or indeed absent.

The second group of proprietary foods, in the main those which are intended to be an addition to fresh cow's milk, can be similarly subdivided. They consist for the most part of carbohydrates of varying degrees of complexity. Some, often derived from wheat flour, have their starch broken down to soluble carbohydrates, dextrins, etc., in the process of manufacture. Others, of similar derivation, only undergo this change when they are actually prepared with milk. The starch in these is not always completely converted and care must therefore be taken in their selection and preparation. It has been pointed out in the preceding chapter that a baby of less than six months of age is not equipped to digest carbohydrate in the form of starch. The third class in this group consist of those preparations which contain unmodified starch and may be regarded as transitional farinaceous foods to the porridge, bread, and puddings of older infancy.

The practice of adding vitamins to dried proprietary foods is increasing. Many of those enumerated in the table are prepared with sufficient vitamins A, C, D, to supply a baby's requirements. In choosing a dried milk it is necessary to find out from the manufacturers how much of the vitamins the reconstituted milk will contain and, further, whether there is likely to be any deterioration in the vitamin content with storage or in the course of preparation with water or milk. These should be clearly stated on the label.

If there is any doubt about the actual vitamin content of the milk, the baby must be given, in addition, an adequate ration of orange juice and cod-liver oil or other vitamin-containing supplements.

WEANING

For the breast-fed baby this stage consists of an introduction to forms of food other than human milk. It should start at the end of the seventh month, proceed by easy stages and be complete by the end of the first year. From the seventh to the ninth month breast feeding will still be the infant's chief source of food; but he will be accustomed during this time to taking at least one of his meals in some other form. From the ninth to the twelfth month, nursing having been discontinued, he will be persuaded to rely on an increasing variety of form in his diet. During this latter period cow's milk must continue to provide the essentials of his food.

The first stage for the breast-fed infant, from the seventh to the ninth month, is concerned not so much with an alternative meal, as with accustoming him to other flavours and other textures of food. Thus the two o'clock breast feed is at first replaced by a seven-ounce feed of cow's milk; later this is thickened in slow stages with one or other cereal until it is porridge-like and the baby takes from the spoon. Simultaneously a "first course" of yolk of egg, scraped cooked meat or pounded fish with mashed potato and gravy is instituted. Sieved vegetables are added. At nine months the infant, although otherwise fed at the breast, realizes he can enjoy and digest food of a different consistency and of a variety of flavours.

For the bottle-fed baby much of this has been done long before; yet for him also it is desirable to provide one educative meal of the same sort once a day between the ages of seven and nine months. Both for the breast-fed and the bottle-fed baby the end of the ninth month should set a term to essential milk feeding. During the following three months, three of the five feeds should be progressively varied to become eventually breakfast, dinner and tea. The other two should remain for a time in a *vestigial* form as drinks of milk (later water) in mid-morning and at bedtime. The time of the early morning feed is retarded to a more socially acceptable hour. At first it will be merely seven ounces of milk thickened with cereal, later bread and milk and bread and bacon fat. Similarly, the six o'clock feed will be advanced to five or earlier and passing through the stage of thickened milk becomes bread and butter, cake and a drink of milk. In the middle of the day yolk of egg, sieved vegetable, scraped meat and pounded fish followed by thickened milk will become minced meat, poultry or fish with vegetables and gravy, followed by a simple milk pudding and sieved stewed fruit. If fashion or family tastes decree, finely shredded raw vegetables and fruit can be incorporated in the later stages.

TRANSITIONAL DIET

After weaning—which should take place not later than the tenth month—the diet becomes of a more solid character. The same principles must be observed in its composition, however, as in the case of infants; that is to say, the building material and fat must be relatively more largely represented than in the diet of adults.

The importance of a sufficiency of protein in the diet of children can hardly be exaggerated. Much of the feebleness, flabbiness, and pallor of the children of the poorer classes in large towns is no doubt due to a lack of it. There is reason also to believe that a similar deficiency may be a cause of the stunted and ill-developed bodies which such children often show. The dearness of meat is largely responsible for these conditions.

The ***total daily Calories*** required at different ages are approximately as follows (Holt):[1, 2]

	Boys.	Girls.
1 year	950	940
5 years	1490	1410
10 ,, ...	2330	2200
15 ,, ...	3855	3235
20 ,, ...	3265	2640

The protein requirement amounts to 4 grammes per kilo of body-weight at the age of one, the amount diminishing to about 2·5 grammes per kilo at the age of six, and remaining at this value until the end of growth. The amount of ***fat*** should be equal to the protein, and the balance of the Calorie requirement should be derived from carbohydrates, the exact quantity of which will vary with the activity of the child.

Roughly speaking, a child of five requires half as much fat and building material as a full-grown adult doing a moderate amount of work, but only one-third as much carbohydrate; while a boy of fifteen will require even more of every ingredient than a full-grown man doing moderate muscular work.

One must now say a few words as to the sources from which the different ingredients of the diet should be derived.

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[1] For a discussion of principles see EMMETT HOLT'S *Food, Health, and Growth.* (New York: The Macmillan Co., 1922.)

[2] See more modern figures, pp. 61–63.

Even for some time after weaning, cow's milk should still be the chief source of protein. It may be supplemented at the end of the first seven months by small quantities of yolk of egg, and chicken, fish, and a little underdone meat may gradually be added. These animal substances are the best sources of protein, because they contain it in a concentrated and easily-digested form. It is possible, however, to rear healthy children on a diet the protein part of which is almost entirely derived from vegetable sources, especially if the child is able to lead an active and out-of-door life.

In most cases, however, it is safer to supply about two-thirds of the total protein required in an animal form.[1]

The best vegetable protein-yielders for children are oats (oat flour, groats, and rolled oats), wheat (whole-wheat flour, macaroni, semolina, or such patent wheat foods as Opmus and Florador), such preparations of maize as hominy and cerealine, and, amongst the pulses, lentil flour.

Fat should be derived from such sources as good milk, butter, the yolk of egg, and bacon. Difficulty is often found in getting the child to take enough fat, but its importance in the diet is such that pains should be taken to educate the child in this respect. By giving it in a state of fine division the difficulty may often be overcome. Thus, butter spread on bread or mixed with mashed potato may be taken when more solid fat would disagree or be refused. Suet pudding also contains fat in an easily-digested form.

If any ***carbohydrate*** is added to the diet before the teeth are cut, it should, as we have seen, be chiefly in the form of sugar or dextrin. Even up to the end of the first year it is well to avoid starchy foods, unless in very limited amount. It is at this period that one of the patent foods, in which the starch is partially digested, may be of service. After the first year more solid starchy food may be given. Rice, potato and oat flour are the most easily digested forms. Biscuits or rusks, too, are more easily digested than ordinary bread, because the high degree of heat to which they have been exposed ruptures many of the starch grains, and converts part at least of their contents into soluble forms.

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[1] "During the period of growth," says Clement Dukes (*School Diet*, p. 32), "there should be a tolerably even balance between the amounts of farinaceous and vegetable food, with a large preponderance of animal food, the total supply required being largely in excess of that demanded by adults, in order to supply the material necessary for growth and development as well as wear and tear." He is assuming, of course, that regular daily exercise is enforced. He is of opinion that growing boys should have meat twice a day—once to make good wear and tear, and once to provide for growth. The total daily allowance should be 9½ oz. of cooked meat.

The following is an analysis of two such preparations:

Rusks (Montgomerie's)	Dr. Jago's Analysis.
Water	6·9
Protein	11·5
Starch	60·4
Maltose	14·2
Other soluble matters	6·0
Phosphoric acid	0·3
Rest of Mineral elements	0·4

Dorina Nursery Biscuits	Dr. Gregory's Analysis.
Water	7·94
Protein	9·41
Starch	47·33
Maltose	16·62
Dextrin	10·58
Fat	9·88
Mineral elements	1·24

Robb's Nursery Biscuits are also a serviceable preparation of a similar sort, as are Cow and Gate rusks.

Bipsine Rusks are made from malted wheat with the addition of casein. They contain 15 per cent. of protein, and are said to be rendered more digestible by having been treated with pepsin. Nurso Rusks [1] are very similar. Both of these are of much higher nutritive value than ordinary rusks.

Arrowroot, cornflour, Oswego, sago and tapioca are useful forms of starch, which may be given in the form of puddings, but they possess no advantage over rice, and it must be remembered that they are practically devoid of protein.

Sugar is one of the most important forms in which carbohydrate can be added to the diet of children. The great reduction in the price of sugar which has taken place since the end of the last century is probably one of the causes of the improved physique of the rising generation. The fear that sugar may injure children's teeth is exaggerated. The negroes, who live largely on sugar-cane, have the finest teeth the world can show. If injudiciously taken, sugar may, however, injure the child's appetite and digestion. The craving for sweets which children have is no doubt the natural expression of a physiological need, but they should be taken with, and not between, meals. Boiled sweets are the most wholesome. Jam is also an important vehicle for adding carbohydrate to the dietary. In Victorian nurseries it was the rule to have either jam or butter, never the two together. We point out that so great is the importance of fat in the diet of childhood, and so few the forms in which it can be given when compared with the abundant choice of different varieties of carbohydrate, that one must on no account allow jam to replace butter, or even dripping, as the habitual accompaniment of the child's bread.

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[1] Callard and Co.

The inorganic constituents, which are so important for building up the bones, muscles and blood of the growing child, should be chiefly derived, during the first two years at least, from milk. Abundance of milk in the diet will ensure a sufficient supply of the three most important ingredients—calcium, potassium and phosphorus. Eggs, too, are rich in these elements, and the yolk of egg especially shares with milk the advantage of containing much phosphorus in an organic form. Iron is contained in yolk of egg, green vegetables (spinach is an exception), liver, and in such vegetable substances as oatmeal and the unmilled cereals. The iron is probably unavailable in cereals with phytates in them.

The salts of potassium, which occur so abundantly in fruits and green vegetables, are also of importance, and such articles should always find a place in the child's menu. These foods are also a valuable source of vitamins A and C.

Of beverages it need merely be said that water is the only one suited for young children, but care should be taken that it is pure. Alcohol in all forms should be avoided as being entirely unnecessary for healthy children. Tea and coffee are also harmful to the susceptible nervous system of the child, but cocoa, made with plenty of milk, may be allowed, though it should be regarded, like milk, as a food rather than a beverage properly so called.

The following schemes of diet for young children illustrate the practical application of the above principles:

I. Diet from 9 to 12 Months

First Meal, 7.30 a.m.

Milk thickened with groats, oat-flour, Chapman's Whole Wheat Flour, Mellin's Food, Savory and Moore's Food, Allenbury No. 3, Cream of Wheat, or Patent Barley.

Second Meal, 10.30 to 11 a.m.

Warm milk.[1]

Third Meal, 1.30 to 2 p.m.

Warm, thickened milk, preceded by the yolk of a lightly boiled or raw egg, or scraped or pounded fish with purée vegetables.

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[1] All milk must be sterilized by boiling. For this purpose it is necessary to heat it until it just comes to the boil, when it should be immediately cooled.

Fourth Meal, 5 p.m.

Same as first.

Fifth Meal, 9 to 10 p.m.

Warm milk.

During this period the use of a bottle should be gradually discontinued, and the child fed with a spoon or accustomed to drink out of a feeding-cup or ordinary cup.

The amount of milk taken in the course of the day should not exceed 2 pints. If the child is thirsty, he may be given a little water between meals.

From about the eighth month onwards, something to chew should be given occasionally, such as a rusk or crust, or a piece of sponge cake or stale bread-and-butter.

Two teaspoonfuls of orange juice may be given daily and, in the winter months, some fish-liver oil.

II. Diet from 12 to 18 Months

First Meal, 7.30 a.m.

A breakfast-cupful of milk thickened with groats, fine oatmeal, whole-wheat flour, or hominy.

Bread or rusks and milk as a change; bread fried in bacon-fat.

Second Meal, about 11 a.m.

A cupful of warm milk.

Third Meal, 1 to 1.30 p.m.

Sieved potato and vegetables with gravy and scraped meat or pounded fish; as a change, the yolk of a lightly boiled egg.

Some milky rice or bread pudding, with the addition of some of the pulp of a roasted apple or the pulp of stewed prunes.

Fourth Meal, 5 p.m.

Milk and bread-and-butter and plain cake.

Fifth Meal, 9 p.m.[1]

Warm milk.

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[1] The sooner this late drink can be omitted the better. It delays the acquisition of nocturnal continence of urine. It's place must be taken by bigger drinks of milk earlier in the day.

III. Diet from 18 Months to 3 Years

First Meal, 8 a.m.

Porridge and milk, followed by the yolk of a lightly boiled egg or bread dipped in bacon-fat. Stale bread, crisp toast or a rusk.

Milk to drink.

Second Meal, 12.30 to 1 p.m.

A little pounded or minced chicken or underdone meat or fish with green vegetable and mashed potato.

Milk pudding and stewed fruit.

Water to drink.

Third Meal, 4.30 p.m.

Bread-and-butter; sponge or other plain cake occasionally.

Milk.

Fourth Meal, 6.30 p.m.

Warm milk or milk soup.

A little fresh fruit should be given daily and some fish-liver oil in the winter.

CHAPTER XXI

THE PRINCIPLES OF FEEDING IN DISEASE

In this and the succeeding chapter we shall consider the use of food as a therapeutic agent in the treatment of the sick. In dealing with this part of the subject, it will be well to confine our attention as far as possible to the discussion of principles, and to avoid those detailed instructions for the dietetic management of particular cases which find their appropriate place in text-books of therapeutics. If the general principles involved are once fairly grasped, the knowledge we have already acquired as to the composition and uses of different foods should be sufficient to guide us in drawing up a dietary suited to any ordinary case of illness. Nor can one deal in such a book as this with the methods of preparing food for the sick, or invalid cookery, no matter how important some acquaintance with that art must always be to the practical physician.

In deciding upon the dietetic management of any case of disease it is important to bear in mind, what is often forgotten, that a patient is not a mere bundle of separate organs, but an organic whole, and that the diet must often be directed to the needs of the man rather than to those of his malady. The evil results of a forgetfulness of this fact are often seen. A patient's general nutrition may become seriously impaired, for instance, through well-intentioned efforts to lighten the labours of his stomach. Thus it has only just been realized that many of the diets used in the treatment of gastric disorders are either wholly deficient, or contain a minimum, of ascorbic acid. Patients who have had these diets for some time are in the subscurvy state as shown by the amount of ascorbic acid they assimilate before the excess is excreted in the urine (see p. 164). The important factor of idiosyncrasy must also be borne in mind, and full recognition made of the fact that different individuals react differently to the same diet just as they do to the same drugs. Nor must it be supposed, as the laity are apparently tempted to do, that diet is a universal panacea which can be counted upon to prevent or to cure all diseases. On the contrary, it has, like other remedial agents, only a limited place in therapeutics, and the few diseases which specially lend themselves to dietetic treatment may be divided into the following groups: (1) Fevers; (2) disorders of metabolism, e.g. diabetes, obesity, gout; (3) affections of the stomach and bowels; (4) disorders of the circulation and blood; (5) diseases of the organs of excretion.

But before one passes to the separate consideration of these groups, it is advisable to point out a few ***practical rules*** which should always be present in one's mind in drawing up any scheme of diet for a patient. They are these:

1. A special plan of diet must be drawn up and the foods which are forbidden must be specified. In a few cases, only the latter need be mentioned.

The next two rules are corollaries to the first.

2. Before recommending any food it is well to ascertain whether the patient likes it, and how it agrees with him.

3. A food should not be forbidden unless there is a good reason for so doing.

4. Unless there is some strong contra-indication, attention should always be paid to the wishes and tastes of the patient. This rule was first formulated by Hippocrates in the aphorism, "Such food as is most grateful, though not so wholesome, is to be preferred to that which is better, but distasteful"; and Sydenham recognized its value when he wrote: "More importance is to be attached to the desires and feelings of the patient, provided they are not excessive or dangerous, than to doubtful and fallacious rules of medical art."

5. If food disagrees, it should be deleted from the dietary and later on given in small amounts. If this is well tolerated the quantity taken can be increased.

6. Changes of diet should, if possible, be made gradually.

7. A diet should never be prescribed for a patient without having first ascertained what his habits are as regards work and exercise.

These rules require no comment.

1. *Principles of Diet in Fever*

There are few departments of practical medicine in which opinion has undergone a greater revolution than in the question of fever diet.[1] Hippocrates fed his fever cases simply upon wine and "ptisan," or thin barley gruel, and this lowering plan, first practised for centuries on the sole weight of his authority, was afterwards endorsed by the erroneous pathological doctrine first promulgated by Broussais, that fevers proceeded from irritation of the intestinal mucous membrane, and therefore demanded a starvation diet. His contemporary, Brown, though perhaps not much nearer the truth in his pathology, was better advised in his practice when he taught that fevers were " asthenic " diseases, and required to be treated by liberal feeding. It was not until about the middle of the nineteenth century, however, that Graves, discarding all pathological doctrines, and guided simply by the results of observation, came to the conclusion that the popular starvation method was wrong, and introduced the modern practice, ever since adopted, of " feeding fevers."

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[1] For a full account of the history of the subject, see J. UFFELMANN, (1877), *Die Diät in den Acut-fieberhaften Krankheiten.*

The prevailing system at the present time may be fairly described as that of feeding a fever patient up to the limits of his digestive capacity with fluid or semi-fluid food, except, perhaps, in the case of some abdominal conditions. The reaction against starvation diets, in the opinion of some physicians, has gone too far, while others are of the opinion that even now insufficient amounts of food are given.

Any lingering doubts as to the wisdom of the feeding plan tend to be dispelled by the results of researches which have shown (1) that the free administration of food does not, as was formerly supposed, tend to raise the temperature of feverish patients ; and (2) that the food is not merely poured into a digestive apparatus unable to deal with it, for the absorption of light articles of diet, at any rate, goes on as perfectly in the febrile as in the non-febrile state.

It has been shown that a great increase of metabolism occurs during fever and Coleman and Du Bois [1] found in cases of typhoid fever that the basal heat formation rises and falls in a curve roughly parallel with the temperature, and at the height of the fever is 40–50 per cent. above the normal.

It is important to consider how the caloric requirements are supplied. If a healthy patient is starved the fat and protein of the body supply the bulk of the Calories which are produced. Thus Benedict [2] estimated the metabolism of a starving healthy man, and the average figure for the seven days showed that 1690 Calories were used per day and these were supplied by 139·8 grammes of fat, 69·5 grammes of protein, and only 23·6 grammes of carbohydrate. The chief loss of weight is due to the consumption of fat, though the weakness of the muscles attracts especial attention to the destruction of protein. In the seven days of the fast 486·5 grammes of protein were used, which must have come from the muscles; this figure multiplied by 4·8 gives the weight of flesh lost, i.e. 2·33 kilogrammes = 5·12 lb. The loss of muscle is well shown by F. von Müller's experiment. He gave a patient a diet of 1000 Calories containing 51·8 grammes protein (8·29 grm. nitrogen). The patient lost on balance 86·4 grammes of nitrogen in 8 days and this is equivalent to a loss of 540 grammes of protein or 2·59 kilogrammes of flesh (5·7 lb.).

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[1] Coleman, W., and Du Bois, E. F. (1915), *Arch. Int. Med.*, 15, 887.

[2] Cit. Graham Lusk. (1928), *Science of Nutrition*, Fourth edition, 98.

METABOLISM OF S.A.B. DURING A SEVEN-DAY FAST
(after Benedict).

Day.	Grammes.			Calories.				R.Q.	Urine.	
	Protein.	Fat.	Glycogen.	Calculated from Metabolism.	Directly Determined.	Per Kg.	Per Sq.M.		Ratio N : S.	Ratio N : P_2O_5.
1 . .	73·4	126·4	64·9	1796	1765	29·7	941	·78	19·6	8·55
2 . .	74·7	147·5	23·1	1790	1768	29·9	946	·75	18·6	5·55
3 . .	78·1	153·0	5·4	1785	1797	30·8	969	·74	17·38	6·34
4 . .	69·8	144·7	25·2	1734	1775	30·8	966	·75	16·11	4·83
5 . .	65·2	144·7	8·2	1636	1649	29·0	905	·74	16·26	5·23
6 . .	64·4	129·8	21·7	1547	1553	27·5	856	·75	16·27	5·19
7 . .	60·8	132·5	18·7	1546	1568	28·0	869	·74	16·28	4·87
Average	69·5	139·8	23·6	1691	1696	29·3	922	·75	17·2	5·79

The work of Shaffer and Coleman,[1] and Coleman and Du Bois,[2] on the metabolism of typhoid fever, has shown that the average metabolism of a patient with typhoid fever is 40 Calories per kilogramme, or 2400 for a man of 65 kilogrammes (10 stone 3 lb.). They found that the basal metabolism might be increased by 40–50 per cent. when the temperature was 104° F. (8 per cent. for each degree Fahrenheit). A healthy man was easily kept on a nitrogenous equilibrium on this number of Calories, but the typhoid patient required 52–80 Calories per kilogramme (3600–5000). It is difficult to understand what happens to this great excess of Calories. Coleman and Du Bois showed that the protein, fat, and carbohydrate were perfectly digested and absorbed and that some fat might be deposited in the tissues, although protein loss was continued. They also found that the specific dynamic action of protein was much reduced or even absent. The great disturbance in metabolism is believed to be due to the action of toxin and not to the actual height of the temperature, since Graham and Poulton[1] showed that destruction of proteins did not occur although the temperature, which was artificially raised, was above 39° C. (102° F.) for 2–3¾ hrs. in four experiments.

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[1] SHAFFER, P. A., and COLEMAN, W. (1909), *Arch. Int. Med.*, **4**, 538.

[2] COLEMAN, W., and DU BOIS, E. F. (1915), *Arch. Int. Med.*, **15**, 887.

The principles of dietetic treatment in fever are (1) to give an adequate amount of protein, 75–87·5 grammes of protein (12–14 grammes nitrogen), yielding 307–350 Calories, is considered to be sufficient ; (2) to give a high caloric value up to 80 Calories per kilogramme (5200 Calories for a man of 65 kilogrammes). The carbohydrate should provide from 56–60 per cent. of the total, i.e. 2900–3100 Calories, leaving 1800–2000 Calories to be supplied by the combustion of 194–215 grammes of fat. The protein is best given in the form of milk and eggs : 3 pints = 1680 c.c. supplies 60 grammes, and 3 eggs supply 18 grammes. The carbohydrate may be given in the form of sugar, and lactose is usually preferred to glucose as it is less sweet, but some patients dislike it. The sugar is usually added to the milk, but may be given in the juice of oranges, lemons, grape-fruit, or pineapple, according to the patient's taste, as a change of flavour is often of great assistance. The milk may be flavoured with tea, coffee, or cocoa, or mixed with meat extracts. Additional carbohydrate can be given in the form

High Caloric Diet for Typhoid Fever

	C.	P.	F.	Cals.	C.	P.	F.	Cals.
7 a.m.								
8 oz. Milk . . .	10	7·2	8·8	152				
½ oz. Biscuit . .	10	1	2·5	70				
					20	8·2	11·3	222
9 a.m.								
Egg (scrambled with butter from allowance)	—	6·8	7·0	92				
1 oz. Bread . .	15	2	—	70				
½ oz. Dry Oatmeal	10	1·5	1	59				
8 oz. Milk for tea and porridge .	10	7·2	8·8	152				
					35	17·5	16·8	373
11 a.m.								
4 oz. Orange-juice (sugar from allowance) . . .	10	—	—	41				
1 oz. Biscuits . .	20	2	5	140				
					30	2	5	181

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[1] Graham, G., and Poulton, E. P. (1912–13), *Quart. Jour. Med.*, 6, 82.

HIGH CALORIC DIET FOR TYPHOID FEVER—*continued*

	C.	P.	F.	Cals.	C.	P.	F.	Cals.
1 *p.m.*								
3 oz. White Fish	—	15	—	61				
4 oz. Milk for white sauce	5	3·6	4·4	76				
3 oz. mashed, old Potatoes	15	—	—	61				
2 oz. Blancmange	10·5	2	2	70	30·5	20·6	6·4	268
3 *p.m.*								
4 oz. Milk in tea	5	3·6	4·4	76				
1½ oz. White Bread	22·5	3	—	105				
½ oz. Honey, Syrup or Jam without seeds	10	—	—	41	37·5	6·6	4·4	222
5 *p.m.*								
8 oz. Milk	10	7·2	8·8	152				
½ oz. Ovaltine, Benger's Food, or Bournvita	10	2	1	57	20	9·2	9·8	209
7 *p.m.*								
1 Egg (poached or lightly boiled)	—	6·8	7·0	92				
1 oz. Toast	15	2	—	70				
4 oz. Orange-juice	10	—	—	41				
8 oz. Milk as junket	10	7·2	8·8	152	35	16·0	15·8	355
9 *p.m.*								
8 oz. Milk with	10	7·2	8·8	152				
½ oz. Ovaltine (or Benger's Food, etc.)	10	2	1	57				
½ oz. Biscuit	10	1	2·5	70	30	10·2	12·3	279
ALLOWANCE FOR THE DAY: 3 oz. Sugar					85	—	—	348
3 oz. Butter					—	—	72	660
3 oz. Thick Cream (40%)					1·5	1·5	35	336
					324·5	91·8	188·8	3452

Note.—If it is found that the caloric value is insufficient, sugar and fat are easily added. Extra protein can be given either in the form of extra eggs and milk or as dried household milk.

of puddings made with rice or semolina, mashed potatoes and gravy, and oatmeal, or the proprietary foods like Benger's or Farex. The extra fat should be given in the form of cream 300–400 c.c. of 20 per cent. cream. The feeds should be given two-hourly by day and four-hourly by night.

When this high Caloric diet is used a careful watch must be kept on the stools for signs of undigested material, and if these appear, the amount of food should be reduced, and in some cases very considerably. We have taken typhoid fever as our type, but the same principles apply to other fevers, and the convalescence from these would be much shorter if more food were given. A patient with influenza often has little appetite and does not want to eat meat or fish, but eggs can be added to milk and 200–400 grammes of sugar can be added to lemon or orange drinks, and thus raise the caloric value considerably. Even in a short fever at least 2000 Calories should be given if possible and in a long one this should be increased to over 3000. Fish and meat should be given as soon as the patient's appetite returns, but in rheumatic fever meat and meat extracts should not be given.

The use of ***alcohol*** in fevers is an important matter which calls for some special discussion. Hippocrates recognized the value of wine in fever, and since his time it has been pretty generally employed. Stokes of Dublin laid down certain imperative indications for its use, and his colleague Graves devoted one of his clinical lectures to a consideration of the place which it should take in the general treatment of fever. The advantages of alcohol, however, were insisted upon more strongly by Todd,[1] about the middle of the nineteenth century, than by any preceding English author. By the end of the nineteenth century the administration of brandy had become a routine treatment, and 1, 2, or 3 oz. were given every four hours to most of the ill patients and even to young children. Since then opinions about the use of alcohol in disease have altered considerably.

Alcohol was strongly recommended for the following conditions :

(1) Failing circulation, as exhibited (i) in a persistently rapid pulse (120 or more), or if it be weak, irregular, unequal, or dicrotic ; (ii) by a faint or inaudible first sound of the heart.[2]

It is difficult to understand how alcohol can be of much value in any of these conditions. Higgins showed that alcohol causes a slight quickening of the pulse rate and that this may last for thirty minutes. This quickening suggested that the myocardium was definitely stimulated by the alcohol, and Dixon, working on the isolated rabbit heart, observed a slight stimulant action. This is denied by other workers, and would in any case be of little value. The blood pressure does not rise after alcohol because it has no direct stimulant action on the vaso-motor centre, but if the amount taken is sufficient to cause excitement the blood pressure may rise. Alcohol produces a change in the distribution of the blood since the skin becomes red and flushed. This increased blood supply to the skin would cause a greater pulsation in the radial artery, and would suggest that alcohol was a cardiac stimulant.

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[1] *Clinical Lectures on Certain Acute Diseases*. London, 1860. Page 438.

[2] STOKES. (1839), *Dublin Med. Journ.* (1st series), 15, 1.

These considerations suggest that no reliance should be placed on alcohol for the treatment of cardiac affections.

(2) Nervous exhaustion, as manifested by sleeplessness, low delirium, and tremors. Alcohol has a depressing effect on the higher centres of the brain. The depression which results therefrom is often of value in aiding sleep as the patient becomes more tolerant of his troubles. If the patient is unaccustomed to alcohol, ½ or 1 oz. of whisky may be sufficient to ensure sleep, but if he habitually takes 4–6 oz. at bed time, smaller amounts will be valueless. A low delirium and tremors would probably be made worse by alcohol.

(3) Failure of digestive-power, as indicated by inability to take food, and diarrhœa. Alcohol is often taken by patients who suffer from indigestion as they are thereby enabled to eat their meals better. This is a bad practice as the patient is thereby induced to eat food which his stomach cannot tolerate and is better without. Further, alcohol by itself tends to cause a gastritis and so intensifies the damage already done to the stomach. It has no effect in checking diarrhœa.

(4) High temperature, especially if persistent. Alcohol is of some value in lowering the temperature as it dilates the peripheral vessels and therefore causes an increased loss of heat. It is now recognized that the fever is often beneficial to the patient and (unless the patient is in danger of developing a hyperpyrexia, i.e. a temperature rising rapidly to 108°) alcohol should not be used for this purpose.

(5) A bad general condition—e.g. in feeble, exhausted, elderly, or alcoholic subjects. Alcohol is frequently given under these conditions and may induce the patient to take food which he would not otherwise do. It should not be pressed on patients if they dislike it, as its real value is very small. It is often necessary to give it to patients who feel miserable or who cannot sleep without any alcohol, but it should only be given in small amounts. If a patient cannot eat his meals without alcohol it is probable that some definite lesion of the stomach is present and the patient should be examined from this point of view.

(6) As a food. Alcohol has a high Caloric value as 1 gramme yields 7 Calories. It is, however, burnt very slowly in the body, only 10 c.c. (8 grammes) of absolute alcohol can be oxidized an hour and these yield 56 Calories. This amount is given by ⅔ oz. of brandy, 45 per cent.; or 1⅓ oz. of whisky (post-war) 20–25 per cent. The maximum amount of brandy which could be oxidized in twenty-four hours is thus 16 oz. (whisky 32 oz.) and would contain 192 grammes of absolute alcohol. This amount of alcohol would yield 1344 Calories. A patient, who was unaccustomed to alcohol, would be made very drunk although a seasoned toper might be unaffected. It is probable that ½ oz. of brandy every four hours by day and once in the night (i.e. 5 doses) is as much as most patients can stand, though double or treble the dose used to be given. This would give 36 grammes in the day and 252 Calories. This number of Calories is supplied by 61 grammes of sugar and is better tolerated by all patients unless they habitually take large amounts of alcohol. It must be remembered that all the alcohol is not burnt, for some of it is excreted in the urine and is thus lost.

The Kind of Alcohol. Some authorities have laid great stress on the types of alcohol used. They believe that a preparation rich in volatile esters like genuine cognac is much better than ordinary brandy or whisky, but there is no pharmacological evidence that this is the case. A good dry champagne has been recommended in the treatment of vomiting and was formerly much used.

The views about alcohol are those which we have formed from the consideration of the physiological evidence and of the medical experience of one of us, but we thought it desirable to consider the current practice as shown by the amount of wines and spirits ordered in eight different hospitals.

Cost of Alcohol consumed at Nine Hospitals

Hospital.	No. of Beds in 1938.	1903 £	1908 £	1913 £	1918 £	1923 £	1928 £	1933 £	1938 £
A . .	670	717	559	323	482	644	281	72	26
B . .	300	77	42	31	86	182	115	55	51
C . .	673	171	48	28	112	172	180	82	73
D . .	649	368	133	238	276	308	174	123	102
E . .	849	545	298	143	381	519	398	168	125
F . .	476	246	79	70	80	164	149	205	182
G . .	436	—	—	—	—	484	345	424	289
H . .	601	224	97	88	205	522	438	297	332
I . .	642	—	—	136	294	252	272	316	374

The table shows the cost of the wines and spirits at nine hospitals in London and big towns, and is the actual cost in the years 1903, 1908, etc. The number of beds shown is the figure for 1938, and in many cases is greater than it was in 1903, and in one case (H) is nearly double, owing to the presence of many patients with cancer. The price of alcohol was much greater in the years immediately after the 1914–1918 war than it was before then.

The results are interesting and show that in six out of eight hospitals the consumption is considerably smaller than it was in 1903, but that the decrease is very uneven. Thus in one big hospital the cost in 1903 was £717, the biggest figure of the series, and is now only £26, while in a small hospital the cost was £77 and has only decreased to £51; in another big hospital it has decreased from £545 to £125. In two hospitals, however, the opposite has taken place, and the cost in one case has risen from £224 to £332, but it must be pointed out that the number of beds has nearly doubled and now includes many patients dying of cancer. The figures for the other hospital are most remarkable as they have risen from £136 in 1913 (figures for 1903 are not available) to £374 in 1938, or nearly fourteen times as much as that of hospital A which has about the same number of beds.

On the whole, the figures for the hospitals are in agreement with the views we have set out.

The figures for the different kinds of alcohol used in hospital A in 1903 and the succeeding years are shown on page 584, together with that used in 1938 in four other hospitals, and reflect the opinions in the different hospitals.

The figures vary in a surprising way. Brandy is most used in all five, but apart from this there is no common factor and the figures must be allowed to speak for themselves.

The figures for beer and stout are not included in the table on the opposite page. The consumption of these is still considerable, for, at St. Bartholomew's Hospital, the cost is about £60 a year. They are chiefly prescribed for elderly patients (usually after surgical operation) who either cannot sleep at night or are miserable without their beer. Many of these patients are accustomed to drink a good deal of beer.

2. *Disorders of Metabolism*

The Dietetic Treatment of Diabetes Mellitus

The change which has taken place in the dietetic treatment of diabetes mellitus since this book was first published in 1900 is very remarkable. At that time the patients were given a diet con-

Comparison of Consumption of Stimulants, 1903–38

	Port.			Sherry.			Gin.			Burgundy. Bottles.			Whisky.			Brandy.			Rum.			Champagne. Bottles (½)
	G.	P.	Oz.	G.	P.	Oz.	G.	P.	Oz.				G.	P.	Oz.	G.	P.	Oz.	G.	P.	Oz.	
1903 . .	414	1	5	5	5	13	3	5	16	33			23	7	10	370	6	15	1	2	2	98
1908 . .	236	2	4	1	2	13	1	1	0	120			12	0	19	260	5	5	—	—	—	184
1913 . .	212	2	3	20	7	15	2	0	10	38			2	1	2	233	4	13		2	0	147
1918 . .	154	7	1	—	—	—		6	12	91			1	2	17	155	1	2	1	1	0	126
1923 . .	103	5	4	3	4	0		3	0	46			2	5	0	77	7	4		3	0	104
										G.	P.	Oz.										
1928 . .	19	5	5		4	9	1	4	7	3	6	15		3	16	66	3	9			10	85
1933 . .	4	5	4	—	—	—			6	1	5	4	—	—	—	11	2	3	—	—	—	17
1938 . .	1	4	12	1	0	12	—	—	—	2	0	0		3	13	5	7	12		2	12	10
The figures for four other hospitals in 1938 were as follows:																						
E. . . .	14	3	10	10	7	9	1	3	3	0	6	0	7	0	12	19	5	13	0	1	8	68
F. . . .	0	7	4	—	—	—	—	—	—	3	0	0	1	7	1	47	3	6	—	—	—	16
K. . . .	—	—	—	—	—	—	—	—	—	2	0	13	0	3	14	6	4	12	—	—	—	37
L . . .	0	5	6	0	1	0	0	0	4	0	2	16	0	3	6	28	16	9	—	—	—	46

taining 100–150 grammes of protein, 250 grammes or more of fat and very little carbohydrate. The protein of the diet was high because of the different so-called diabetic foods which were eaten. The best of these contained no carbohydrate at all, though in many of them the carbohydrate was little reduced. The former were unpalatable whereas the latter were less so, in proportion as they contained more carbohydrate.

If an abrupt change was made from an ordinary diet to a very strict one the glycosuria disappeared in the mild cases, whereas coma might rapidly supervene in the severe ones. Such tragedies led to a change in treatment and the carbohydrate was gradually reduced from 100 grammes to 20 grammes. In the mild cases the thirst and glycosuria disappeared and the patients' health improved. But if a patient had a severe diabetes the amount of acetone bodies gradually increased and sometimes exceeded 50 grammes in the day, while the glycosuria did not disappear. Van Noorden introduced an improved treatment for this type of case. This consisted of a diet of eggs, vegetables, and butter, which was eaten for two days followed by one of 150 grammes of well-cooked oatmeal and 200 grammes of butter for another two days, and then by the egg and vegetable diet for another two days. This régime was unpleasant, but always caused a great decrease in the acetone bodies and glycosuria, but as soon as the original high protein and fat diet with little carbohydrate was given the condition rapidly deteriorated.

Guelpa introduced the fasting treatment which he combined with saline purgatives. This treatment caused the disappearance of the glycosuria but it returned as soon as the original diet was given.

F. M. Allen's striking contribution was the gradual increase in the diet after a fast of sufficient duration to get rid of the glycosuria. The fast might only be of two or three days' duration, but might last ten days or longer in severe cases before the glycosuria disappeared. When this occurred the protein and fat of the diet were gradually increased but the carbohydrate was kept at 20–30 grammes in the day. If the glycosuria returned a further fast was prescribed until it disappeared. This treatment was a great advance on the old treatment, and patients often ceased to pass sugar although the carbohydrate in the diet was raised to 50 grammes or more. In the severe cases the diet would consist of C. 20–40 grammes; P. 100 grammes; and F. 125–200 grammes; caloric value 1700–2400. The condition tended to relapse and the patients with the severe disease gradually lost weight, strength, and energy, though this was partly due to the repetition of the fast necessitated by the return of glycosuria. This state of under-nutrition, although of great immediate benefit to the patient, caused great privations. Some workers thought that the effect of the under-nutrition was worse than the disease and in 1922 had already abandoned the fasting treatment for a so-called maintenance diet which contained C. 40–50 grammes; P. 70–80 grammes; F. 125–150 grammes; calories 1600–1900. The introduction of insulin by Banting and Best in 1922 caused such a great improvement in the general health of patients that at first little change in the composition of the diet occurred. This was partly due to the high cost of insulin, 25*s.* per 100 units compared with the present price of 1*s.* 6*d.* per 100 units.

In 1926 Sansum and others [1] reported the case of a man who said that he must have more carbohydrate in his diet. They found that the patient was much better in health when given more carbohydrate and more insulin, and that the amount of insulin required was much less than anticipated. Since that time the amount of carbohydrate has been steadily increased and now varies from 150 to 250 or even 350 grammes; co-incidentally the amount of fat has been decreased from 250 to 100 or even to 50 grammes when the diet contains 350 grammes of carbohydrate. The amount of protein has remained unchanged at 70 to 100 grammes.

The problem of treating a patient with diabetes is still not an easy one as patients of all ages develop the disease and have very different dietetic requirements. Few doubt that the general health of all patients is benefited by the giving of insulin and a well-balanced diet, but many older patients refuse to have it. If they are fat, diet alone may be tried with advantage, but if they are thin, insulin should always be recommended. It is therefore necessary to consider other forms of treatment.

The Under-nutrition Diet. This consists of giving a diet of very little food value, i.e. tea, coffee, with a little milk, gravy soup, lemonade, and plenty of water. The fast used to be maintained until the glycosuria disappeared, but nowadays is usually broken after one or two days, irrespective of whether the glycosuria has gone or not. The diet used to be increased gradually so that 10 days might elapse before it contained 100 grammes of carbohydrate. Nowadays a diet containing this amount is often given at once.

The diet is usually chosen in an arbitrary manner, but it can be calculated in the following manner and is then called a *maintenance* diet as it is sufficient for the basal needs of the body.

The figures for the basal needs of young children and adolescents are given in a table (p. 50). Those for adults are obtained from the Boothby and Sandiford nomograph, p. 48. An approximate result can be obtained by multiplying the patient's weight by 11·3. Thus an adult who weighs 132 lb. will require 132 × 11·3 = 1491 Calories, and this is divided between the protein, carbohydrate, and fat in the following way:

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[1] Sansum, W. D., Blatherwick, W. R., Bowden, R. (1926), *Amer. J. Med. Assoc.*, **86**, 178.

The amount of protein is first settled.
An adult requires about 0·5 grammes of protein per 1 lb. of body-weight
A child of 12 ,, ,, 1·0 grammes ,, ,, 1 lb. ,, ,, ,,
,, ,, ,, 6 ,, ,, 1·5 grammes ,, ,, 1 lb. ,, ,, ,,
,, ,, ,, 2 ,, ,, 2·0 grammes ,, ,, 1 lb. ,, ,, ,,

An adult weighing 132 lb. should be given 66 grammes of protein, and this figure multiplied by 4·1 (the caloric value of protein) gives 270·6 Calories and leaves 1221 for the carbohydrate and fat. The amount of carbohydrate should not be less than 100 grammes. This figure multiplied by 4·1 = 410 Calories; 1221 minus 410, leaves 811 Calories for the fat. This figure divided by 9·3, the caloric value of fat, gives 87·2 grammes for the fat of the diet. The diet is then prescribed as carbohydrate 100 grammes, protein 66 grammes, fat 87 grammes, Calories 1497. This diet is divided into four meals of approximately the following amounts: breakfast, lunch, and dinner, C. 30 grammes, P. 21 grammes, F. 27 grammes, Cal. 460; tea, C. 10 grammes, P. 3 grammes, F. 6 grammes, Cal. 109.

A sample diet (p. 588) shows one way in which a diet containing 100 grammes of carbohdrate, 48 grammes of protein and 53 grammes of fat, Calories 1093, can be arranged. The amounts of protein and fat are rather less than in the basal diet and so continue the process of undernutrition. The amounts of carbohydrate taken at each meal should be kept as constant as possible though the amount of protein and fat need not be so accurate. The diet should be varied as much as possible and the food tables (pp. 593–5) which are very simple, make it easy to do this. The diet contains twenty 5-gramme portions of carbohydrate and about seven 7-grammes protein—5 grammes fat portions, with the addition of half an ounce of butter, and these can be varied at will. If it is desired to increase this diet to that necessary for the basal needs of the patient weighing 132 lb., three 7-gramme protein—5-gramme fat portions with the addition of two-thirds of an ounce of butter, i.e. 21 grammes protein and 35 grammes fat should be added to the diet.

When a patient with a mild diabetes is given such a diet the glycosuria may disappear and if so the amount of the carbohydrate should be increased by 10 grammes every three or four days until a diet of 130 or 150 grammes is reached, provided that the urine passed after the evening meal is sugar-free. The amount of protein and fat may also be increased. A diet containing 150 grammes of carbohydrate, 73·4 grammes protein, and 97·4 grammes fat, Calories, 1814, is set out on p. 590.

Example 1[1]

Diet for an Adult—

	C.	P.	F.	Cal.	C.	P.	F.	Cal.
Breakfast :								
1 oz. bread or toast .	15·0	2·4	0·3	70				
2 5-gm. portions of fruit or ½ oz. jam .	10·0	—	—	41				
					25·0	2·4	0·3	111
Midday Meal :								
Gravy Soup . . .	Negligible food value.							
2 oz. meat or 2 oz. white fish and ½ oz. butter	—	14·0	14·0	188				
6 oz. green vegetables	Negligible food value.							
¾ oz. cheese . . .	—	6·7	8·2	105				
Two 5-gm. portions of fruit. . . .	10·0	—	—	41				
1 oz. bread . . .	15·0	2·4	0·3	70	25·0	23·1	22·5	404
Tea :								
1 oz. bread . . .	15·0	2·4	0·3	70				
					15·0	2·4	0·3	70
Dinner :								
Gravy soup . . .	Negligible food value.							
2 oz. meat or 2 oz. white fish and ½ oz. butter	—	14·0	14·0	188				
2 oz. potatoes . .	10·0	—	—	41				
6 oz. green vegetables	Negligible food value.							
1 oz. bread . . .	15·0	2·4	0·3	70				
One 5-gm. portion of fruit	5·0	—	—	21				
					30·0	16·4	14·3	320
3½ oz. milk in the day	—	—	—	—	5·0	3·7	3·5	68
½ oz. butter in the day	—	—	—	—	—	—	12·5	120
			Totals .	.	100·0	48·0	53·4	1093

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[1] Reprinted, with the permission of the Publishers, from *An Index of Treatment.*

If, however, the glycosuria reappears after a few days with a diet of 100 grammes carbohydrate, the amount of carbohydrate should not be reduced below 100 grammes, as this amount seems to be necessary for the correct metabolism of the fat ; if 80 grammes only are taken ketone bodies usually appear in the urine. The effect of another fast day can be tried but the patient should be advised to start insulin and have a good diet containing 130–150 or more grammes of carbohydrate.

Many elderly patients with small appetites do not want to eat more than 130 grammes but the middle-aged usually prefer 150–170 grammes, while the younger people should have over 200 grammes and some take 300 grammes or over. The amount of fat given under these conditions varies according to the views of different workers. Some give 150 grammes or more, whereas most restrict the fat to 100 grammes or so, and a few insist that if the carbohydrate is raised to over 200 grammes that the fat should be reduced and believe that it should be as low as 50 grammes. There are advantages and disadvantages of this diet : the amount of carbohydrate is so great that a difference of 20 or 30 grammes is negligible and it is unnecessary to weigh the carbohydrate foods accurately, but the amount of fat is so small that many people feel the deprivation either of fatty foods like bacon, which they like, or if they eat bacon they miss the butter.

At present it is not possible to say which is the best diet, but we would put the outside limits as follows : C. 150 grammes ; P. 70–100 grammes ; F. 100 grammes ; Calories 1810–1930 ; and C. 250–350 grammes ; P. 70–100 grammes ; F. 50 grammes ; Calories 1745–2265.

Diets for children and adolescents are a little more difficult to arrange as they require more food than adults to enable them to grow and develop properly. The number of Calories required by children is shown on p. 50 and the amount of protein on p. 587, and these figures are of use in arranging the diets. It is suggested that those over the age of 12 should be given about 60 per cent. of the caloric allowance for full activities. The initial diet should contain 150 grammes of carbohydrate and the full diet for an adult, Example 2, can be used. When the patients begin to take exercise the carbohydrate must be increased and the protein raised to 1 gramme per lb. of body weight. Children about 12 can also be started on the same diet and the diet increased later, but the final requirements should be about 66 per cent. of the full values.

Children of about 6, weighing 3 stone, need 1550 Calories for their full activity and it is suggested that the initial diet should contain 70 per cent. of this amount, i.e. 1080 Calories. The diet

EXAMPLE 2

HIGH-CARBOHYDRATE DIET—

	C.	P.	F.	Cal.	C.	P.	F.	Cal.
Breakfast :								
1 egg	—	6·4	5·7	80				
1 oz. bacon . . .	—	5·1	15·0	160				
1 oz. bread or toast .	15·0	2·4	0·3	70				
Two 5-gm. portions of fruit, say 4 oz. apples	10·0	—	—	41				
½ oz. ordinary jam or marmalade . .	10·2	—	—	41				
					35·0	13·9	21·0	392
1 a.m. :								
½ oz. biscuit . . .	—	—	—	—	10·0	1·6	0·2	48
Midday meal :								
Gravy soup . . .	Negligible food value.							
3 oz. meat (or 3 oz. salmon) . . .	—	21·0	21·0	282				
3 oz. potatoes . .	15·0	—	—	61				
6 oz. green vegetables	Negligible food value.							
Two 5-gm. portions of fruit, 4 oz. orange	10·0	—	—	41				
1 oz. bread . . .	15·0	2·4	0·3	70				
					40·0	23·4	21·3	454
Tea :								
⅔ oz. bread . . .	—	—	—	—	10·0	1·6	0·2	48
Evening meal :								
Gravy soup . . .	Negligible food value.							
2 oz. meat (or 2 oz. white fish and ½ oz. butter) . . .	—	14·0	14·0	188				
3 oz. potatoes . .	15·0	—	—	61				
6 oz. green vegetables	Negligible food value.							
1 oz. bread . . .	15·0	2·4	0·3	70				
¾ oz. cheese . . .	—	6·7	8·2	105				
Two 5-gm. portions of fruit or ½ oz. cheese biscuit	10·0	1·6	0·2	48				
					40·0	24·7	22·7	472
11 p.m. :								
¾ oz. biscuit . . .	5·0	0·8	—	24				
3½ oz. milk . . .	5·0	3·7	3·5	68				
					10·0	4·5	3·5	92
In the whole day :								
3½ oz. milk . . .	—	—	—	—	5·0	3·7	3·5	68
1 oz. butter . . .	—	—	—	—	—	—	25·0	240
	Totals . .				150·0	73·4	97·4	1814

is determined in the following way: The protein should be 68 grammes, allowing 1·5 grammes per lb. of body weight. The carbohydrate should be at least 100 grammes. These two account for 689 Calories, leaving 1085 – 689 = 396 Calories for the fat. This number divided by 9·3, the caloric value of fat, gives 43 grammes for the fat ration. This diet is then prescribed as C. 100, P. 63, F. 43, Cal. 1085. The example below shows one way in which approximately this amount of food can be divided to make a palatable diet. The amount of fat is slightly higher than in the calculation. If it is desired to give the exact amount of fat some of the whole milk must be exchanged for skimmed milk.

Example 3

Diet for Child of Six—

	C.	P.	F.	Cal.	C.	P.	F.	Cal.
Breakfast:								
3½ oz. milk	5·0	3·7	3·5	68				
1 egg	—	6·4	5·7	80				
1 oz. bread	15·0	2·4	0·3	70				
Two 5-gm. portions of fruit	10·0	—	—	41	30·0	12·5	9·5	259
First Drink:								
3½ oz. milk					5·0	3·7	3·5	68
Mid-day Meal:								
2 oz. meat	—	14·0	14·0	187				
2 oz. potatoes	10·0	—	—	41				
6 oz. green vegetables	Negligible food value.							
⅖ oz. rice	10·0	—	—	41				
3½ oz. milk	5·0	3·7	3·5	68				
1 oz. bread	15·0	2·4	0·3	70	40·0	20·1	17·8	407
Tea:								
3 oz. white fish	—	21·0	—	86				
1 oz. bread	15·0	2·4	0·3	70				
3½ oz. milk	5·0	3·7	3·5	68	20·0	27·1	3·8	224
Second Drink:								
3½ oz. milk					5·0	3·7	3·5	68
⅓ oz. butter in the day					—	—	9·0	84
	Totals				100·0	67·1	47·1	1110

A child of 2 years weighing 26 lb. requires 1150 Calories for his full activities and it is suggested that he should have 75 per cent. of this amount, i.e. 860 Calories. The amount of carbohydrate is settled arbitrarily at 80 grammes which provides 328 Calories. The amount of protein required is also settled arbitrarily at 50 grammes, 2 grammes per lb. of body weight. This provides 205 Calories and leaves 860 − 533 = 327 for the fat. This figure divided by the Caloric value of fat, 9·3, gives 35 grammes for the fat ration. The diet is then prescribed as C. 80, P. 50, F. 35. The example given below shows one way in which approximately this amount of food can be arranged.

EXAMPLE 4

DIET FOR CHILD OF TWO—

	C.	P.	F.	Cal.	C.	P.	F.	Cal.
Breakfast :								
6 oz. milk . .	8·5	6·3	6·0	116				
1 oz. bread . .	15·0	2·4	0·3	70				
1 egg	—	6·4	5·7	80				
					23·5	15·1	12·0	266
First Drink :								
6 oz. milk . .					8·5	6·3	6·0	116
Mid-day Meal :								
1 oz. meat . .	—	7·0	7·0	93				
1 oz. potatoes .	5·0	—	—	20				
3 oz. green vegetables . . .	Negligible food value							
⅖ oz. rice . . .	10·0	—	—	41				
3½ oz. milk . .	5·0	3·7	3·5	68				
					20·0	10·7	10·5	222
Tea :								
6 oz. milk . .	8·5	6·3	6·0	116				
1 oz. fish . . .	—	6·0	—	25				
1 oz. bread . .	15·0	2·4	0·3	70				
					23·5	14·7	6·3	211
Second Drink :								
6 oz. milk . .					8·5	6·3	6·0	116
Totals . .					84·0	53·1	40·8	931

Patients and especially young ones should be allowed to choose which amount of carbohydrate and fat they want and the dose of insulin adjusted to meet these demands ; otherwise they will probably take the food they want after leaving hospital and thus upset the balance of the food and insulin.

The proof of a pudding is in the eating, and if the patient is not having enough food he will either remain underweight or lose weight. If this is the case, the amount of the carbohydrate should be increased, and sufficient insulin given to control the glycosuria.

Food Tables. Diet formulæ appear formidable to anyone who is not accustomed to think about the constituents of the diet, but the food tables which are now in use make it very easy to choose a diet of approximately the right amount. The different articles of food which are in common use are included in the following tables.[1]

CARBOHYDRATE-CONTAINING FOODS

Five grammes carbohydrate are contained in the undermentioned weights of the edible parts of the various foods: any one item, therefore, may be substituted for any other, without risk of serious error. The vegetables are cooked, unless otherwise stated. Each portion provides about 20 Calories.

The carbohydrate food tables, Table I, show the amount of food which contains 5 grammes carbohydrate and are arranged in four classes: (*a*) The vegetables are divided into two groups. Group I includes those which contain so little carbohydrate that they need not be weighed or taken into consideration. Group II includes those which contain enough carbohydrate to make it necessary to weigh the article of food. (*b*) The fruits are arranged in one table. Most of them contain little carbohydrate and two 5-gramme portions make an average helping. (*c*) The nuts. (*d*) The starchy foods. These are rich in carbohydrate and should be carefully weighed.

TABLE I—CARBOHYDRATE

The following articles of food contain approximately 5 grammes of carbohydrate and may be substituted for each other without causing serious error.

Group I.—These vegetables contain so little carbohydrate that they need not be weighed.

	oz.		oz.
Asparagus	16	Mustard and Cress	20
Brussels sprouts	10	Onions	6
Cabbage	18	Radishes	6¼
Cauliflower	15	Rhubarb	18
Celery (raw)	14	Sea-kale	29
Cucumber (raw)	9¾	Spinach	13
French beans	16	Turnips	7
Lettuce (raw)	9¾	Watercress (raw)	25
Marrow	13		

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[1] The food values are calculated from the tables given in the Medical Research Council's Food Tables.

TABLE I—*continued*

Group II.

(*a*) Beans, broad

	oz.		oz.
(*a*) Beans, broad	2½	Parsnips	1½
Beans, haricot	1	Peas (dried)	1
Beetroot	2	Peas (green)	2
Carrots	4	Potatoes	1
Leeks	4		

(*b*) *Fruits* (weighed with stones but no peel).

	oz.		oz.
Apple (raw)	2	Loganberries	5
Apple (stewed)	4	Melon	3½
Apricot (fresh)	3	Orange	2
Bananas	1	Peaches	2
Blackberries	3	Pears	2
Cherries	1½	Pineapple (fresh)	1½
Currants (red or black)	3½	Pineapple (tinned)	½
Damsons	2	Prunes (dried, stewed)	1
Gooseberries (raw, ripe)	2	Plums	2
Gooseberries (unripe, stewed)	10	Raspberries	3
Grapefruit	3½	Strawberries	3
Grapes	1	Tangerines	2
Greengage	1½	Tomatoes	6

(*c*) *Nuts.*

	oz.		oz.
Almonds	1	Hazel nuts	1½
Chestnuts	½	Walnuts	1½

(*d*) *Starchy Foods.*

	oz.		oz.
Biscuit (plain)	¼	Milk	4
Bread	⅓	Oatmeal (dry)	¼
Cornflakes or Force	¼	Rice or tapioca (dry)	⅓
Jam or Marmalade	¼		

Each portion = 5 grammes carbohydrate.

PROTEIN-CONTAINING FOODS

The protein content of food is shown in Table II. Each portion contains approximately 7 grammes of protein and 5 grammes of fat, and can be exchanged for any other portion without causing serious error. Great attention was formerly paid to the exact content of these foods, when the carbohydrate content of the diet was very low, but this is unnecessary, provided that the carbohydrate value of the diet is over 100 grammes. The amounts of protein-containing foods should be weighed at first, but it is unnecessary to continue to do this when the patient has learnt the approximate values of the diet. Elderly people as a rule have a small appetite and often do not want to eat the full protein ration.

TABLE II—PROTEIN AND FAT

The following articles of food contain approximately 7 grammes of protein and 5 grammes of fat and may be substituted for each other without causing serious error.

(*a*) *Meat and Fish and Cheese.*

	Edible Weight. oz.	Additional Butter. oz.
Beef	1	0
Chicken	1½	⅛
Duck	2	0
Ham (lean)	1	0
Herring	1½	0
Kipper	2	0
Lamb	1	0
Mackerel	1½	0
Mutton	1	0
Pheasant	1¼	⅛
Pork (lean)	1	0
Rabbit	2	⅛
Salmon	1½	0
Sardines	1	0
Sweetbreads	1	⅛
Tripe	1¼	¼
Turkey	1¼	⅛
Veal	1	0
White Fish	1½	¼

	Edible Weight. oz.	Reduction of Butter. oz.
Cheese	1	¼
Ham (fat and lean)	2	½
Bacon (raw)	1½	½

Each portion = approximately 7 grammes protein and 5 grammes fat.
= approximately 75 Calories.

(*b*) *Miscellaneous.*

	Grammes of Carbohydrate.	Protein.	Fat.	Calories.
3 oz. Bread	45	7·2	0·9	210
1 Egg	—	6·8	7·0	92
8 oz. Milk	10	7·2	8·8	152

FAT-CONTAINING FOODS

The following fatty foods should be carefully weighed as it is important to restrict their amount. The following portions contain about 5 grammes of fat:

TABLE III

Cream (average)	⅓ oz.
Cream (Devonshire)	¼ "
Butter or Margarine	⅙ "

How to Use the Food Tables. Intelligent patients soon learn to arrange a diet and vary it so that it is not monotonous. If the patient finds difficulty in doing so, the diet can be ordered as so many carbohydrate and protein-fat rations. Thus a diet of 100 grammes carbohydrate, 66 grammes protein, and 84 grammes fat, can be ordered as twenty 5-gramme carbohydrate (Table I) and nine protein-fat rations (Table II). The nine protein-fat rations contain 45 grammes fat and the remaining 39 grammes are supplied by 1½ oz. butter. The three principal meals of the day should be about equal and contain 6 carbohydrate rations and 3 protein-fat rations, leaving 2 carbohydrate rations for tea. If the carbohydrate ration is increased by 30 grammes, two 5-gramme rations are added to the three principal meals. If the protein-fat ration is insufficient, it is better to add one protein-fat ration, i.e. 7 grammes protein and 5 grammes fat, to the midday and evening meals.

One of the remarkable points, in view of what is said on page 52 about the standard caloric value of 3000 for a man, is the smallness of the caloric value recommended in all these diets. The modern diabetic patient is well, regains the weight which he lost and maintains it. In some cases the patient actually gains too much weight, and it is necessary to reduce the diet once more. Children, moreover, also grow and develop properly on diets containing less than 2000 calories, and it was remarkable that most of them did so on the old diets containing 50 grammes of carbohydrate in use before 1930, though some of them have not grown much. The girls usually pass through puberty all right, though some who have had a high carbohydrate diet for years fail to do so, whereas others did so on the low carbohydrate ones.

In a few cases it is necessary to increase both the protein and the fat to over 100 grammes before the patient gains weight, though it is rare that more than 2400 calories are needed.

The Arrangement of the Diet with and without Insulin. If no insulin is given, a diet containing 100 grammes carbohydrate should be divided between four meals in equal amounts, thus: Breakfast 25 grammes, Lunch 25 grammes, Tea 25 grammes, and Dinner 25 grammes.

If one dose of insulin is given in the morning the proportion should be: Breakfast 35 grammes, Lunch 30 grammes, Tea 15 grammes, Dinner 20 grammes.

The insulin is usually given half an hour before breakfast and half an hour before the evening meal. The balance of a diet of 150 grammes of carbohydrate should be: Breakfast 45 grammes, Lunch 45 grammes, Tea 15 grammes, and Dinner 45 grammes.

If a diet of 200 or 250 grammes of carbohydrate is given, the same balance between the meals should be maintained.

If patients are liable to have an overdose, before lunch and before midnight " buffer " meals should be given—thus, with a 150-gramme carbohydrate diet : Breakfast 40 grammes, " Buffer " 10 grammes, Lunch 40 grammes, Tea 15 grammes, Dinner 35 grammes, " Buffer " 10 grammes ; or with a diet of 210 grammes carbohydrate, Breakfast 50 grammes, " Buffer " 15 grammes, Lunch 55 grammes, Tea 15 grammes, Dinner 60 grammes, " Buffer " 15 grammes.

With the Slow-acting Insulins. The action of these is slow, so that the carbohydrate eaten early in the day must be reduced and that eaten later in the day increased. If two doses of protamine insulin (Delay) are used, the diet should be arranged as follows :

C. 150 grammes. Breakfast 30 grammes, Lunch 45 grammes, Tea 30 grammes, Dinner 45 grammes.
C. 200 grammes. Breakfast 40 grammes, Lunch 55 grammes, Tea 40 grammes, Dinner 65 grammes.

If each dose of protamine insulin (Delay) is mixed with soluble insulin the diet should be arranged as follows :

C. 150 grammes. Breakfast 30 grammes, " Buffer " 10 grammes, Lunch 30 grammes, Tea 30 grammes, Dinner 40 grammes, " Buffer " 10 grammes.
C. 200 grammes. Breakfast 45 grammes, " Buffer " 10 grammes, Lunch 45 grammes, Tea 40 grammes, Dinner 50 grammes, " Buffer " 10 grammes.

If one dose of protamine or globin zinc insulin is given, which have a slower action than protamine, the carbohydrate in the earlier part of the day must be still more reduced and a " buffer " added before breakfast, thus :

C. 150 grammes. With insulin 10 grammes. Breakfast 25 grammes, Lunch 25 grammes, Tea 30 grammes, Dinner 50 grammes, " Buffer " 10 grammes.
C. 200 grammes. With insulin 15 grammes. Breakfast 35 grammes, Lunch 35 grammes, Tea 40 grammes, Dinner 60 grammes, " Buffer " 15 grammes.

If a mixture of soluble and protamine zinc insulin is given in one dose the breakfast must be increased.

C. 150 grammes. With insulin 10 grammes. Breakfast 30 grammes, " Buffer " 10 grammes, Lunch 30 grammes, Tea 30 grammes, Dinner 30 grammes, " Buffer " 10 grammes.

C. 200 grammes. With insulin 15 grammes. Breakfast 45 grammes, "Buffer" 10 grammes, Lunch 45 grammes, Tea 30 grammes, Dinner 45 grammes, "Buffer" 10 grammes.

It must be remembered that patients vary very much in their reaction to insulin and the balance of the diets suggested should be changed according to circumstances.

The dose of insulin may be small, 5 to 10 units given once or twice a day, but may be large, 50, 100, 200 units, and it is rare for a patient to require more than this amount each day. In emergencies much larger doses may be necessary in order to save life, e.g., 500–1000 units or more.

So-called Diabetic Foods. Before the discovery of insulin, these foods, especially bread and biscuits, were of some value to the diabetic. Some which contained little or no carbohydrate were of especial value, but unfortunately were often unpalatable. Others which still contained a considerable amount of starch together with an increased quantity of protein and fat were less unpalatable, but often caused the glycosuria to persist. Fortunately, with the discovery of insulin, and the introduction of the high carbohydrate diet, they are no longer used for the patients who are taking insulin. Unfortunately many elderly patients dislike the thought of a daily injection and prefer to eat an unpalatable diet. The so-called diabetic breads and biscuits are of value until the patients suffer so much from their ill-health that they are persuaded to start insulin and to eat palatable foods once more. The following is a list of some of the foods on the market in 1939:[1]

Bread

	Starch. per cent.	Protein. per cent.	Fat. per cent.
Callard's—			
Seven types, varying from	0–4·75	33·6–78·2	0–12·1
Cheltine—			
Five types, varying from	28·6–35·0	29·8–39·3	2·0–2·8
Energen	45	36	5·7
Heudebert—			
Six types, varying from	9·8–62·94	19·9–77·2	0·68–6·83
Procea	37	20	5·6
Profarin	17·6	30·0	trace
Biscuits			
Allsoy	0·7	32·8	39·4
Callard's—			
Sixteen types, varying from	0–2·87	21·5–72	11·8–56

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[1] Some of these products may be unobtainable.

BISCUITS—*continued*

	Starch. per cent.	Protein. per cent.	Fat. per cent.
Cheltine—			
Ten types, varying from .	20–52·2	25–52	9·5–20·8
Heudebert	62·94	19·99	6·83
Huntley & Palmer (Akoll) .	trace	57·8	32·5
Profarin—			
Two types	,,	30·8–40·0	tr.–24·6

CAKES

	Starch. per cent.	Protein. per cent.	Fat. per cent.
Callard's—			
Six types, varying from .	0–3·0	14·5–20·7	11–33
Heudebert—			
(Chocolate Batons and Croquettes)	19·03	—	34·28

FLOUR

	Starch. per cent.	Protein. per cent.	Fat. per cent.
Allen & Hanbury's . .	1·0	82·0	1·0
Callard's—			
Nine types, varying from .	0–3·5	0–77	0·3–70·2
Cheltine—			
Six types, varying from .	15–58	28–62·5	1·5–13·5
Heudebert	28·15	50·93	2·45
Profarin	nil	63·4	nil

The reader should consult :

(1) JOSLIN, E. P. (1940), *The Treatment of Diabetes.*
(2) LAWRENCE, R. D. (1944), *The Diabetic Life.*
(3) ABRAHAMS, M., and WIDDOWSON, E. M. (1937), *Modern Dietary Treatment.*
(4) GRAHAM, G. (1946), *Index of Treatment.* Hutchison & Hilton.

CHAPTER XXII

THE PRINCIPLES OF FEEDING IN DISEASE (*continued*)

The Dietetic Treatment of Obesity

The occurrence of obesity is an indication of a disproportion between the intake of potential energy in the form of food and the output of actual energy in the form of work. Sometimes the fault lies in an unduly large income, sometimes in too small an expenditure; not unfrequently both factors co-operate.

The popular belief that an individual is fat because he is a large eater may or may not be true. Some patients are fat because they eat large amounts of food and take little exercise; others, although they eat ordinary amounts and take moderate exercise; and others again although they eat very little food and take much exercise. The common factor producing obesity is the eating of more food than the patient needs. To use more scientific language, the caloric requirements of patients vary enormously. The youth of 18 who is doing military training needs 4200 Calories. The man of 21 doing similar work needs 3600. The same man doing sedentary work needs 2500–3000 Calories, while if he is in bed only 2000 Calories. In the last three instances the basal metabolism is supposed to be the same, but the normal limits of variation in the basal metabolic rate are from − 10 per cent. to + 10 per cent. Thus a man whose basal metabolic rate is + 10 would need 2200 while in bed, while if the basal metabolic rate was − 10 he would need only 1800 Calories. If the basal metabolic rate were − 40 per cent., as is the case in myxœdema, only 1340 Calories would be required, while if the basal metabolic rate were + 40 per cent., as is often the case in toxic goitre, 2666 calories would be necessary to maintain weight. These instances show that the needs of the body vary widely and explain the great majority of cases of obesity. Some, however, are not readily explained. Thus Rubner[1] compared the metabolism of a fat boy aged 10 and weighing 41 kilogrammes with that of his thin brother, who was a year older and only weighed 26 kilogrammes. The fat boy took 434 more Calories, but as he was so big the Calories per square metre of body surface were approximately equal, while the Calories per kilogramme were about 8 less for the fat boy than the thin one. This experiment shows that the big frame requires more food than the small one once the condition is established.

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[1] Rubner. (1902), *Beiträge zur Ernahrung im Knabenalter*. Berlin.

Treatment of Obesity. The best-known system is that described by William Banting in 1863 [1] (the verb "to bant" has now passed into the English language). He suffered from an extreme degree of obesity, so great, he tells us, as to render him unable to tie his shoe-strings, and to compel him to go downstairs backwards. He was 62 lb. overweight at the age of 66 and lost 52 of these in the next year. The diet consisted of:

BREAKFAST.

4 to 5 oz. of beef, mutton, kidneys, broiled fish, bacon, or any cold meat except pork; a large cup of plain tea, and a little biscuit or 1 oz. of toast.

DINNER.

5 to 6 oz. of any lean meat or fish, any vegetable except potatoes, 1 oz. of dry toast, some fruit out of a pudding, any kind of poultry or game, and 2 to 3 glasses of good claret, sherry or madeira.

TEA.

2 to 3 oz. of fruit, a rusk or two, and a cup of plain tea.

SUPPER.

3 to 4 oz. of meat or fish as at dinner, and a glass or two of claret.

For a "night-cap" he was allowed a tumbler of "grog" without sugar, or a glass or two of claret or sherry.

On this regimen Banting lost 35 lb. of weight in thirty-eight weeks, which is not surprising, considering that his diet hitherto had consisted of bread-and-milk for breakfast, or a cup of tea with plenty of sugar and milk, and buttered toast; meat, beer, much bread (of which he was always very fond), and pastry, for dinner; a tea of the same composition as breakfast, and a fruit tart or bread-and-milk for supper. He found sugar the most fattening of all foods, 5 oz. of it in a week causing his weight to rise 1 lb.; and he calls milk, sugar, beer, and butter "human beans," because they have the same effect in the human subject that beans have in the case of the horse, and he regards these articles as "the most insidious enemy an elderly man with a tendency to corpulency can possess, though eminently friendly to youth." He adds: "I can conscientiously assert that I never lived so well as under the new plan of dietary."

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[1] BANTING, WILLIAM. "A letter on corpulence addressed to the Public." London, 1863.

The approximate value of this diet excluding the alcohol is carbohydrate 80 grammes, protein 84–105 grammes and fat 80–100 grammes, Calories 1480–1650. The caloric value of this diet is considerably less than that required by a healthy man lying in bed, i.e. 2000, and Banting was up and about; the carbohydrate portion is very small, the fat ration somewhat reduced while the protein at 84–105 grammes is less than that which Voit allowed for the Bavarian peasant, 120 grammes, but is more than the average individual eats. Most patients lose weight on this and similar diets but many complain of feeling limp and tired, and abandon all dieting as being too unpleasant. These complaints were difficult to understand until the introduction of insulin by Frederick Banting and Charles Best in 1921. We now know that these symptoms are due to hypoglycæmia and are a sign that the diet is deficient in carbohydrate for a patient who produces a normal amount of insulin. Experience shows that the amount of carbohydrate necessary to prevent the feeling of hunger and limpness is 100 grammes or more, and varies between 125 and 150 grammes in individual cases. This amount of carbohydrate thus supplies from 410 to 615 Calories.

The value of protein and fat for the body is very different. The obese patient already has large stores of fat deposited in his body and the object of treatment is to make him use these and so free his organs and depots. The amount of fat in the diet should therefore be as small as is compatible with the pleasures of the table. It is possible to reduce the amount of fat to 50 grammes without causing much deprivation, but even this amount yields 465 Calories. If the patient is obese and much overweight the fat can be reduced to 28 or 16 grammes, but these diets are definitely unpalatable and must be specially prepared. The patient who really wants to lose weight can learn to adapt himself to these restrictions. Protein is essential for the repair of the body but it is unnecessary to give the large amounts of 80 to 105 grammes recommended by Banting. Chittenden found that he and his laboratory workers and active students maintained nitrogenous equilibrium on 36 grammes of protein, but many workers prefer to give more protein and so make use of the specific dynamic action of the protein.

The chief difficulty in causing a patient to lose weight is to decide how much to reduce the caloric value of the diet. It is suggested that a diet containing carbohydrate 130 grammes, protein 52·0 grammes, fat 51·0 grammes, Calories 1205, is a suitable one for the initial treatment. It gives a fair variety and can be taken by an intelligent patient who has some of his meals away from home. Diet I provides plenty of green vegetables, either cooked or raw, and fruit and would contain an adequate amount of the vitamins

DIET I

	Carbohydrate.	Protein.	Fat.	Calories.
BREAKFAST.				
1 Egg	—	6·8	7·0	92
2 oz. Bread.	30	4·8	0·6	140
Two 5-gramme portions of Fruit, say 4 oz. Apple.	10	—	—	41
½ oz. Jam or Marmalade. . .	10	—	—	41
MIDDAY MEAL.				
2 oz. Lean Meat	—	14·0	10·0	150
3 oz. Potatoes	15	—	—	61
Green Vegetables to taste . .		Negligible		
1 oz. Bread.	15	2·4	0·3	70
TEA.				
1 oz. Bread.	15	2·4	0·3	70
Lettuce and medium-sized Tomato if desired		Negligible		
EVENING MEAL.				
3 oz. steamed white Fish . .	—	15·0	—	66
3 oz. Potatoes	15	—	—	61
Two 5-gramme portions of Fruit, say 4 oz. Orange	10	—	—	41
8 oz. Milk in the day . . .	10	7·2	8·8	152
1 oz. Butter in the day . . .	—	—	24·0	220
600 I.U. of vitamin D should be given each day.	130	52·6	51·0	1205

This diet contains twenty-six 5-gramme carbohydrate portions and seven 7-gramme protein—5-gramme fat portions, with the addition of ½ oz. of butter. The diet should be varied with the aid of the Food Tables. The egg may be omitted from the breakfast meal and the equivalent amount of protein and fat taken at the midday or evening meal.

A, B, and C, but would probably be deficient in the fat-soluble vitamin D. Fortunately this can be given in concentrated form and at least 600 I.U. of vitamin D should be given each day. Neuburgh [1] prefers to use a diet containing carbohydrate 85 grammes, protein 75 grammes, fat 42 grammes, Calories 1000, which while it provides more protein reduces the carbohydrate to a level at which the patients may, in our opinion, complain of the symptoms of hypoglycæmia.

The patients taking these diets live on their own fat and so remain in nitrogenous equilibrium, and keep well for an indefinite period. They should lose weight slowly, 1 or 2 lb. a week until a reasonable weight for the height and age is reached. When this occurs the caloric value should be gradually increased and a careful watch kept on the weight. Many patients either do not begin to lose weight or lose very little until they have taken a diet for 14 days or even longer. This is thought to be due to retention of water in the tissues. Anderson [2] thought that this was due to retention of salt since a reduction in the salt content of the diet caused an immediate decrease in weight. It seems wiser to leave the salt content of the diet at a normal level and explain to the patient that the initial delay in the loss of weight is due to the retention of water. The use of diuretics like mersalyl which cause a diuresis and so a sudden loss of weight is unnecessary if the patient is intelligent and co-operative.

A patient may often start losing weight if he takes a diet containing only 100 grammes of carbohydrate, on either one or two days a week. This is best taken in the form of fruit, and the following portions of fruit each contain 25 grammes of carbohydrate, and can be varied according to taste.

PORTIONS CONTAINING 25 GRAMMES OF CARBOHYDRATE

4 oz. Orange-juice
½ oz. Sugar

8 oz. Lemon-juice
¾ oz. Sugar

6 oz. Melon
½ oz. Sugar

6 oz. Pineapple-juice

4 oz. Tomato-juice
1 Pear
1 Orange

3 oz. Grapes
4 oz. Plums

Tea and coffee may be taken as desired, with a very small amount of milk.

Lettuce, cucumber, watercress, and mustard and cress can be taken as desired.

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[1] NEUBURGH, L. H. (1942), *Arch. Int. Med.*, **70**, 1033.

[2] ANDERSON, A. B. (1944), *Quart. Journ. Med.*, **13**, 27.

The disadvantages of this procedure is the loss of nitrogen, some 6–7 grammes a day, which must ensue from the lack of protein in the diet. This entails the break-up of 37–44 grammes of protein which will be derived from the muscles. The pure fruit and vegetable diet should be used only occasionally.

If the patient is either very fat or, after four weeks, loses weight when taking Diet I very slowly or not at all, the diet should be reduced to carbohydrate 102 grammes, protein 42 grammes, fat 21·7 grammes, Calories 787 (Diet II, p. 606) or to carbohydrate 71·4 grammes, protein 34·5 grammes, fat 23·4 grammes or 8·4 grammes, Calories 661–502 (Diet III, p. 607). The use of these diets will cause a more rapid loss of weight and provided additional vitamin D is added to the diet no ill effects will ensue. These diets contain so little fat that it is difficult for patients to have their meals away from home or special diet kitchens. The treatment is best started in a hospital or nursing home so that the patients may learn how to arrange and vary their diets. If these patients complain of tiredness and loss of energy at certain times of the day an additional 10 grammes of carbohydrate taken, before the onset of the symptoms, will usually arrest them. It is most important to treat these symptoms promptly so as to make the patients feel well for otherwise they may relinquish the diet before any real benefit has resulted.

OTHER MEASURES.

(1) *Restriction of fluids.* This was advocated by Dancel in 1864. He allowed his patients only 7 to 14 oz. of fluid a day. Oertel allowed 2¼ pints while Von Schweninger gave 3 pints a day, but insisted that the fluid should not be drunk at meals. It has been shown that the restriction of fluids has no direct influence though it may have an indirect one by reducing the amount of food which is eaten. It is probable, too, that one reason why restriction of fluids has given better results on the Continent than is seen in this country is, that in Germany at least, restriction of fluids used to be synonymous with restriction of beer.

(2) Exercise is very disappointing in its effects as walking a mile uses up only 100 Calories which would be supplied by a little less than one and two-thirds ounces of bread.

(3) *The administration of substances which raise the Basal Metabolic Rate.* The most important of these is thyroid extract. It is often ordered if the patient fails to lose weight after a reasonable period of dieting. It should only be used if an estimation of the Basal Metabolic Rate has shown that it is between — 10 per cent. and — 5 per cent. If it is given, the Basal Metabolic Rate should

DIET II

	Carbo-hydrate.	Protein.	Fat.	Calories.
BREAKFAST.				
Tea with Lemon	—	—	—	—
1½ oz. Bread	22·5	3·6	0·4	105
Two 5-gramme portions of Fruit, say 4 oz. Orange	10·0	—	—	41
MID-MORNING.				
Unsweetened Lemonade or Marmite	—	—	—	—
Medium-sized Tomato and Lettuce		Negligible		
Bran Biscuits	—	—	—	—
Two 5-gramme portions of Fruit, say 4 oz. Apple	10·0	—	—	41
MIDDAY MEAL.				
3 oz. Meat (lean)		21·0	15·0	225
Green Vegetables		Negligible		
Three 5-gramme portions of Fruit, say 3½ oz. Grapefruit and 2 oz. Prunes (or 3 oz. Tinned Pears, Peaches, or Apricots) . . .	15·0	—	—	61
Food-valueless Jelly	—	—	—	—
TEA.				
Tea with Lemon	—	—	—	—
1 oz. Bread.	15·0	2·4	0·3	70
Medium-sized Tomato and Lettuce		Negligible		
SUPPER.				
3 oz. steamed white fish . .	—	15	—	66
2 oz. potatoes	10·0	—	—	41
Green vegetables to taste . .	—	Negligible		—
Four 5-gramme portions of Fruit, say 8 oz. Orange	20·0	—	—	82
Bran Biscuits	—	—	—	—
½ oz. Butter in the day . . .	—	—	6·0	55
750 I.U. of vitamin D should be given each day.	102·5	42·0	21·7	787

This diet contains twenty and a half 5-gramme carbohydrate portions and five 7-gramme protein—5-gramme fat portions. The diet should be varied with the aid of the Food Tables, pp. 593–5.

Diet III

	Carbohydrate.	Protein.	Fat.	Calories.
Breakfast.				
Tea with Lemon	—	—	—	—
1 oz. Bread	15·0	2·4	0·3	70
¼ oz. Jam	5·0	—	—	20
Midday Meal.				
3 oz. Meat (lean)	—	21·0	15·0	225
or		or		
4 oz. White Fish		20·0	—	85
Green Vegetables	—	—	—	—
Two 5-gramme portions of Fruit, say 4 oz. Apple or 4 oz. Pear	10·0	—	—	41
Food-valueless Jelly	—	—	—	—
Tea.				
Tea with Lemon	—	—	—	—
½ oz. Biscuit	10·0	1·6	0·2	46
Lettuce	—	—	—	—
Supper.				
10 gramme Cocoa	6·4	1·1	0·7	39
1 Egg	—	6·8	7·0	92
⅔ oz. Bread	10·0	1·6	0·2	46
Salad	—	—	—	—
Three 5-gramme portions of Fruit, say 6 oz. Grapefruit	15·0	—	—	61
Bran Biscuits	—	—	—	—
	71·4	34·5 or 33·5	23·4 or 8·4	661 or 502

Butter nil.

1000 I.U. of vitamin D should be given each day.

This diet contains thirteen 5-gramme carbohydrate portions and gives about four to five 7-gramme protein—5-gramme fat portions.

be estimated at monthly intervals to make certain that it is not raised above + 10 per cent. The indiscriminate administration of thyroid extract in doses of 2–5 grains for long periods may cause symptoms of hyperthyroidism or apparently determine the onset of glycosuria.

The use of other substances which raise the basal metabolism has been suggested. Dinitrophenol has this property but is apt to produce toxic symptoms. Dodds and Pope [1] found that dinitro *o*-cresol was more potent and less toxic than dinitrophenol. Dodds and Robertson [2] found that a basal metabolic rate of + 50 per cent. could be maintained with a dose of 0·5–1 milligramme per kilogramme (0·25–0·5 milligramme per lb.) of body-weight, but toxic symptoms were produced with bigger doses. Since then fatalities have occurred with the smaller doses and its use is not recommended.

Of the different sorts of ***beverages*** in common use, water and the saline mineral and table waters may be regarded as harmless; but the sweetened effervescing waters such as lemonade, ginger beer, ginger ale, and tonic water should be avoided unless the sugar content of the beverage is ascertained and this amount deducted from the food allowed. Tea and coffee may be freely permitted, if taken with little milk and no sugar. Cocoa is often forbidden, but the amount of nutriment which an ordinary cupful of it contains is so small as to be hardly appreciable. In many people, also, it has the advantage of lessening the appetite for solid food.

Alcoholic beverages should be avoided as far as possible, for alcohol is a direct sparer of fat. If a small allowance is indicated because the patient is unhappy without alcohol, a dry natural wine should be selected, or its alcoholic equivalent of well-matured spirit freely diluted with water. All strong and sweet wines, liqueurs, and malt liquors should be interdicted.

FATTENING DIET

In the previous section we have dealt with the dietetic methods of reducing fat. We have now to consider the means at our disposal for increasing it.

Generally speaking, any excess of food which is supplied to the body beyond the amount required to meet the current outgoings of energy in the form of heat and work will be stored up in the form of fat. One does, it is true, meet with cases in which, owing probably to some failure of assimilative power, it is found to be very difficult to achieve the laying on of fat, even although a considerable surplus of food is supplied, but as a rule one may say that in order to fatten the body one has merely to insure the supply of an excess of food.

It will be obvious that one important means of bringing about such a surplus of income over expenditure is to diminish the outgoings of energy from the body. For this reason, rest, more or less complete, is always an important aid for patients whom it is wished to fatten.

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[1] DODDS, E. C., and POPE, W. J. (1933), *Lancet*, 2, 352.

[2] DODDS, E. C., and ROBERTSON, J. D. (1933), *Lancet*, 2, 1137, 1197.

The diet should contain an increased amount of protein, carbohydrate and fat, but respect must be paid to the likes and dislikes of the patient, since it is useless to order extra meat, etc., which the patient refuses to eat.

Fat itself is the best of all fattening foods, as Rubner has shown that, in the formation of new fat, 100 parts of fat are equal to 248 parts of carbohydrate or 313 parts of protein.

It can be given in the form of cream which is easily added to various articles of diet without causing any distaste on the part of the patient. Butter may be more difficult as the patient may dislike greasy cooking. The fat on meat is very useful for many, but unfortunately the thin people often dislike it. The fish which contain fat like salmon, herring, should be taken in place of white fish.

Carbohydrates are very useful as extra amounts can so easily be added to the diet. It is more useful than fat as a sparer of protein as it will establish a positive nitrogen equilibrium more quickly than fat does. Protein is not such a good fattening agent as the other two but it is very useful in bringing a patient into nitrogenous equilibrium, provided an adequate caloric value is maintained with the aid of carbohydrate and fat. It will only be laid down as muscle when the muscles are either exercised or have wasted in the course of an acute disease. Otherwise the amino-acid groups will be split off and excreted as urea and the carbohydrate fraction will be used to lay down fat.

A fattening diet is wanted in three chief sets of conditions : (1) In convalescence from acute illness ; (2) in wasting diseases, such as tuberculosis ; (3) in some nervous disorders, of which neurasthenia may be regarded as the type.

In ***convalescence.*** If the high caloric diet used in the treatment of patients with typhoid fever has been used (pp. 578–9) the loss of protein and fat should be very small. The great demands for food due to the fever persist for three or more days after the temperature is normal, and after this the diet can be gradually reduced from the 5 or 4000 Calories to 2500 or 3000. This can be done by omitting the extra cream and sugar which was given and adding fish and meat, etc.

If the old-fashioned low caloric diet has been used, a considerable loss of body proteins and fat will have occurred. The Caloric value should be increased by the addition of cream and sugar, and the patent foods like Ovaltine, Benger's Food, Farex, and Horlick's

Malted Milk are all of use. Fish and eggs are added to the diet and when the patient's appetite returns, chicken and meat are appreciated. Jellies, though of little food value, are agreeable to the convalescent and with custard and light milk puddings are well liked. Light and moderate exercise will greatly aid the gain in weight as the patient's muscles will gradually recover their size and become firm instead of flabby.

In ***wasting disease*** the addition of extra milk, cream, and sugar are of great value, and the principles of the diet used for typhoid fever form the basis of the treatment.

In the ***treatment of tuberculosis*** there have been various fashions. At one time it was the custom to give plenty of fat in the form of butter, bacon, pork, salad oil, and cream. Patients as a rule disliked this fatty diet. Later came the belief[1] that a high protein diet increased the richness and bactericidal power of the blood, stimulated leucocytosis, and replaced the waste of the muscular tissues, and diets containing 150 grammes of protein were therefore prescribed. The evidence in support of this hypothesis is still lacking. The modern view[2] is that the dietetics of tuberculosis demands no more than a full well-balanced intake. The current custom is to give diets which are high in caloric value, 3000 to 4000, as for treatment of typhoid fever. If the patient is very ill a fluid diet should be given. The protein is usually made up to about 100–120 grammes with milk, eggs, meat, or fish. The carbohydrate should be about 400 grammes and the fat about 200 grammes. This diet gives a Caloric value of about 4000. If a high fever is present the Caloric value should be increased if possible as the basal metabolism will be raised 7–8 per cent. for each degree rise of temperature Fahrenheit (see p. 576). If the patient is losing weight the Caloric value should be increased by adding to the carbohydrate or fat in the diet. If he gains weight rapidly and is above the normal weight, the amount of carbohydrate and fat should be reduced.

The diet should contain plenty of vitamin D, and this can be supplied by the giving of fish and fish oil, but it is usually advisable to give extra vitamins A and D in a concentrated form, at least 18,000 I.U. of A and 2400 I.U. of D should be given.

TREATMENT OF NEURASTHENIA

The work of Williams, Mason and Wilder (see p. 148), suggests that symptoms very like those of neurasthenia can be produced by diets which contain very little thiamine (vitamin B_1). This may be important in the treatment of this condition. An enquiry should be made into the dietetic habits of the patients.

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[1] BURDOWELL, GOODBODY and CHAPMAN. (1902), *Brit. Med. Journ.*, 449.

[2] KEERS. (1944), *Lancet*, **2**, 599.

Since vitamin B_1 is widely distributed among the foods, it may be found that the total intake of food is small and the diet restricted to a few articles of food which contain little vitamin B_1. The white bread sold before the war 1939–45, contained very little B_1 (0·12–0·30 I.U. per gramme) but the 85 per cent. and 82½ per cent. National bread contained considerably more (1·2 I.U. per gramme) and it is claimed that the 80 per cent. extracted flour contains a trifle more—1.26 I.U. per gramme (35·7 I.U. per ounce).[1] This type of bread or the wholemeal which contains about as much, 0·75 to 1·3 I.U. per gramme, should be eaten. The various meats contain 0·5 per gramme, so that 1 oz. contains 14 I.U. but pig's meat contains considerably more, 62 or more I.U. per ounce. Milk contains 130 I.U. per pint. Thus a diet containing the following foods :

		I.U.
8 oz. Bread, 80 per cent. extraction	=	285
10 oz. Milk	=	65
6 oz. Meat	=	84
8 oz. Potatoes	=	170
8 oz. Vegetables	=	170
		774

gives 774 I.U. or 2·54 milligrammes and should be adequate to prevent any symptoms of neurasthenia.

If, however, the patient will not take sufficient foods of this type or if the symptoms of neurasthenia exist in spite of a diet which contains an adequate amount of vitamin B_1 extra amounts should be given either in the form of Marmite, 30 I.U. per 1 gramme, or Bemax 15 I.U. per 1 gramme, or one of the proprietary preparations (p. 696) should be given, either by mouth or by subcutaneous injection. Williams and Mason ended their experiments with diets containing 130–150 I.U. (0·4–0·45 milligrammes thiamine) by giving 1 milligramme subcutaneously followed by 3 milligrammes a day for a week and then 7·5 milligrammes for an unstated period. The curative dose of a vitamin may be about 10 times the protective dose and 3000 I.U. or 10 milligrammes should be given for about three weeks to patients with neurasthenia. This should be sufficient if a lack of vitamin B_1 is responsible for the condition.

A method of treating ***neurasthenic patients*** called the Weir

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[1] MORAN and DRUMMOND. (1945), *Lancet*, 1, 698.

Mitchell Treatment or Rest Cure was once much used. It consisted of giving a very high Caloric diet, and the details will be found in the 8th Edition (p. 541). It is now no longer used.

Anorexa Nervosa

In this condition the patient must be given a good mixed diet containing an abundance of all the vitamins. The physician must gain the confidence of the patient and induce her to eat in spite of lack of appetite, nausea and abdominal discomfort. A careful watch must be kept on the patient since she may vomit the food and conceal it by various subterfuges.

The work by Williams, Mason and Wilder on the effect of extreme deprivation of vitamin B_1 showed that in the late stages of the experiment a syndrome like anorexa nervosa developed. This work suggests that big doses of vitamin B_1 should be given over and above that in the diet. The dose should be greater than that given to patients with neurasthenia, i.e. 5400 I.U. a day—18 milligrammes a day. This dose should be given until the patient has recovered. In addition full doses of the other vitamins should be given :

say, 100 milligrammes of ascorbic acid daily for four weeks ;
say, vitamin A. . . . 30,000 I.U. a day ;
say, vitamin D. . . . 5000 I.U. a day ;
say, nicotinamide . . . 300 milligrammes a day ;
say, riboflavine . . . 10 milligrammes a day.

These amounts are necessary to make up for the lack of these various vitamins in the diet for many weeks or months. The ordinary food cannot supply these amounts and the various commercial preparations (p. 696) should be used.

The Dietetics of Gout

The exact cause of gout is still doubtful, but it is certainly intimately associated with the metabolism and excretion of uric acid. The uric acid which is excreted in the urine is derived from two sources : (1) Endogenous, which is (*a*) derived from the breakdown of nucleins of cells, and (*b*) synthesized from the amino-acids arising from digestion. (2) Exogenous, from the purines of the foodstuffs.

The amount of uric acid excreted in the urine can be considerably diminished by a healthy adult if a diet is taken which contains no purines, but it can never be eliminated on account of the endogenous uric acid, which varies between 0·5 and 0·7 gramme per day. The amount excreted by gouty patients varies greatly according to the state of health. During an acute attack a great deal may be excreted for a few days, 0·7 to 1 gramme, but then the amount becomes normal (0·5 to 0·7 gramme) for a long or short period. The excretion, however, gradually decreases and may sink to a very small amount (0·10 to 0·20 gramme) just before an attack is due; to be again followed by a copious excretion immediately after the onset of the acute attack, and after repeated attacks the usual output may be very small, 0·20 gramme or less. It is unknown whether the small excretion is due to the combination of the uric acid with some other substance which is excreted by the kidney with difficulty, or to a direct failure of the kidney to excrete uric acid.

If extra nucleo-proteins in the form of pancreas and thymus are given to a gouty patient between attacks, the uric acid excretion is neither so prompt nor so complete as in healthy persons, and in some cases is followed by an actual decrease in the excretion. These facts explain the rationale of the low purine diet. The practice varies from the strict *Haig diet*, in which no purine-containing foods are eaten and no beverages like tea, coffee, or cocoa, because of their content of methyl purines, are drunk—to a moderate diet in which only the ***foods with a high purine content*** are barred.

The Purine Content of Various Foods

	Purine Nitrogen. Grammes per 100 grammes (3½ oz.).		Purine Nitrogen. Grammes per 100 grammes (3½ oz.).
Herring Roe (soft)	0·484	Trout	0·092
Sweetbreads . .	0·426	Whiting . . .	0·090
Whitebait . . .	0·335	Veal.	0·089
Sprats (smoked) .	0·250	Mutton (leg, roast)	0·077
Sardines . . .	0·234	Salmon	0·078
Heart	0·174	Haddock . . .	0·072
Herring . . .	0·172	Chicken. . . .	0·072
Mussels . . .	0·154	Pollack	0·071
Liver	0·143	Bacon	0·069
Kidney	0·137	Pork	0·066
Bloater	0·133	Ham	0·064
Cod's Roe . . .	0·130	Cod	0·062
Goose	0·100	Crab	0·061
Venison. . . .	0·097	Beef (sirloin, roast)	0·060
Pheasant . . .	0·095		

(Less than 0·06 gramme of purine nitrogen per 100 grammes)

Beans
Beef (corned)
Brains
Bread
Eggs
Flour and other cereals
Green-leaf Vegetables
Nuts
Peas
Root Vegetables
Tripe

Foods Free from Purines

Butter
Cheese
Cream
Fruits
Honey
Jam
Marmalade
Milk (fresh or tinned)
Sugar
Vegetable Soups

Beverages Rich in Purines

Cocoa
Coffee
Chocolate
Meat extracts
Meat soups
Tea

Tea, coffee, cocoa, and chocolate are usually allowed in moderation, but the meat extracts and meat soups are forbidden.

There are two foods, soft herring roe and sweetbreads, which contain over 0·400 gramme of purine nitrogen per 100 grammes of edible material, and three, whitebait, sprats and sardines, which contain over 0·234 gramme per cent.; eight foods contain over 0·100 gramme per cent. and seventeen between 0·094 and 0·059 gramme per cent. The difference between these foods is often slight and partly explain the conflicting views on diet. Thus whiting and veal contain 0·090 and 0·089 respectively. Should these be barred while bacon, pork, and cod containing only 0·069 and 0·063 are allowed? Or should all foods which contain more than 0·069 gramme be forbidden?

The decision is a difficult one, and it seems better to lay down some postulates—(1) In the acute attack only foods are allowed which are free from purines; (2) in convalescence from an acute attack, or if the patient is liable to frequent attacks, foods are allowed which are either free from purine or contain less than 0·07 gramme per 100 grammes; (3) in the long intervals between attacks, foods which contain less than 0·1 gramme per 100 grammes are allowed. These restrictions do not entail any real hardship. (4) In patients who have had only one attack, foods containing as much as 0·150 gramme per cent. may perhaps be allowed. It must be remembered that 30 grammes (1 oz.) of sardine or 50 grammes (1¾ oz.) of kidney contain 70 milligrammes, or the same amount as 100 grammes (3½ oz.) of pork or cod and could be exchanged for one another without causing any harm, but the 30 grammes of sardine should not of course be taken as a savoury after the full ration of meat has been eaten. Meat extracts and gravy soups are better avoided altogether as they always contain a good deal of purines. Vegetable soups are allowed.

The cooking of these foods is also much disputed. Some recommend that the food should be plainly cooked and that all highly seasoned dishes and rich sources should be barred. These instructions are difficult to justify on physiological grounds unless the seasoning is done with foods which contain much purines, e.g. shrimp sauce. These rules are probably a relic of the times before the importance of purines was recognized. Similarly, the recommendation that sugar and sweet things should be taken sparingly is probably due to the presence of glycosuria in some gouty patients. It seems unnecessary to forbid all gouty patients to eat sugar because a few have diabetes mellitus.

Beverages. Tea, coffee, and cocoa all contain methylpurines, but there is little evidence that these increase the output of uric acid in health. Haig thought that they should be forbidden, but nowadays they are usually allowed in moderation. Alcohol *per se* is not believed to have any effect in causing gout and it is certain that gout is very uncommon among whisky drinkers. On the other hand, it is common among those races which drink malt liquors like beer and stout, and these should be absolutely forbidden. Wines present a more difficult problem. Red wines like port and claret and burgundy have been responsible for causing attacks in some patients, while a white wine from a neighbouring vineyard may be drunk with impunity. Champagne is also regarded as a precipitating cause of gout, even though other white wines and cider are safe. Some patients are said to be able to take red wines in safety but to suffer from gout after drinking white wines. These observations suggest that it is not the alcohol of the wine but some substance in the red or white wine to which the patient is allergic and is responsible for the tendency to gout. The great majority of patients seem to be able to take white wine and cider without risk, and it is on these grounds that the following table has been constructed, but it must be recognized that red wines may not harm some patients while the white ones may be deleterious.

Drinks to be Avoided

Red Wines Champagne
All Malt Liquors, like Beer and Stout

Drinks Allowed

White Wines, except Champagne
Cider Spirits in moderation

Rheumatoid Arthritis, Arthritis, Osteo-arthritis and Fibrositis

A raw vegetable and fruit diet has been used for the treatment of muscular rheumatism, osteo-arthritis, and rheumatic arthritis.[1]

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[1] Hare, D. C., and Williams, M. B. (1938), *Lancet*, **1**, 20. Hare, D. C. (1936), *Proc. Roy. Soc. Med.*, **30**, 1.

The immediate results are said to be good in a high proportion of cases but no improvement occurred in two old cases of rheumatoid arthritis. The diet was:

DIET I

(Daily Rations. A raw diet continued for two weeks only).

	oz.	
Vegetables	14	Salads, Tomatoes, Roots.
Fruit: Citrus	8	Orange, Lemon, Grapefruit.
Apple	6	
Dried	4	Apricot, Prune, Raisins, etc.
Nuts	2	Brazil, Cashew, Hazel, etc.
Oats, crushed	$\frac{3}{4}$	Served after soaking, uncooked.
Sugar	$\frac{1}{8}$	One lump.
Salad oil	2	Or Heinz Mayonnaise mixed with oil
Cream, 20 per cent.	3	
Milk	12	
Salt	None	
Fluids	unrestricted	Tea, Water, etc.

Food Values (*approx.*).

Carbohydrate	145 grammes
Protein	35 grammes
Fat	143 grammes

Average Caloric value about 2000.

SAMPLE MENU. DIET I

BREAKFAST.

Apple porridge, i.e.—
  Grated Apple.
  Soaked raw Oatmeal.
  Grated Nuts.
  Cream.
Fresh Orange.
Tea with milk and cream.

MID-MORNING.

Tomato purée with lemon.

DINNER.

Salad Dish, i.e. Lettuce, Cabbage, Tomato, Roots, etc. Salad dressing with oil.
Mixed Fruit Salad and cream.

TEA.

Dried Fruits.
Nuts.
Tea with milk and cream.

SUPPER.

Fruit Porridge (Prune, Apricot, Apple).
Salad Dish with dressing.

Bedtime.

Lemon and Orange-juice with hot water.

Diet II

(A modified diet given for periods of several weeks)

After two weeks on the Raw Diet I the following additions were made:

Cooked Foods:	Vegetable soup	
	Eggs	1
	Meat	2 oz.
	Bacon	2 oz.
	Bread	2 oz.
Uncooked Foods:	Butter	1 oz.
	Cheese	1 oz.
	Milk	8 oz. (total milk = 20 oz.)

Salt as present in the food but no added salt.
Oil and cream were reduced as necessary.

Food Values (*approx.*).

Carbohydrate	146 grammes
Protein	66 grammes
Fat	142 grammes

Average Caloric value about 2200.

The preparation and serving of the diets must receive close attention. The green vegetables and roots are finely shredded through a special mincing machine; pulped apple is prepared in the same way and mixed with a little lemon-juice to prevent discoloration. Dried fruits, such as apricots, prunes, and raisins are soaked in water and then pulped or served whole, raw oatmeal too is soaked before serving. Nuts are taken whole or finely ground, sprinkled over the fruit. A good variety of salads and fruits should be obtained and the food daintily served. This attention to detail is mentioned because it is an essential to success, otherwise the food looks and tastes unappetizing and even the willing patient cannot eat it.

The benefits observed in these diseases may be associated with either the high intake of vitamin C as the patients were all in the sub-scurvy state before the treatment was started, or with the low chloride content of the diet.

Fibrositis

Dietetic treatment is of no value.

Gravel

This is the name given to the deposition in the urine of urates and uric acid. These substances are very insoluble in an acid urine,[1] and fall out of solution when the urine gets cold. If the urine is very acid they may be precipitated at body temperature. In this case the gravel will collect in the bladder, and may cause symptoms. In the past it has been suggested that the amount of purines in the diet should be decreased as in the treatment of gout. It is quite unnecessary to do this, as the condition is easily cured by making the urine less acid so that the uric acid may remain in solution, until the urine has been passed. This can be done either by eating more of the foods which produce alkalies and eating less of those which form acids, or by giving a daily dose of alkalies. The foods which produce alkalies and acids are shown (pp. 129–130). It will be seen that milk, fruit, and all vegetables except peas tend to make the urine alkaline while all the sources of animal proteins together with bread, rice, and oatmeal, tend to make the urine acid. The amount of vegetables and fruit in the diet should first of all be increased and if this fails to keep the uric acid in solution an adequate dose of potassium acetate, potassium citrate or potassium bicarbonate should be given. The right dose must be determined by testing the urine with blue litmus paper. The dose may be as large as 2–3 grammes (30–45 grs.) every 3 or 4 hours. Sodium salts do not dissolve urates so well as potassium salts. The urine should not be too alkaline as phosphates prevent the solution of urates.

PHOSPHATURIA

This is due to the urine being too alkaline. It may be clear when passed but precipitate when it is cold or may even be turbid when passed. It is said to occur in neurasthenic patients. It is certainly desirable that the urine when passed should be clear and should not deposit much phosphate on cooling and this is especially the case if the patient has had a phosphatic calculus. The urine can be made more acid by reducing the amount of vegetables and milk and by increasing the amount of animal protein, bread, rice and oatmeal. (See tables, pp. 129–130). If these dietetic changes fail, some acid sodium phosphate 0·6–1·3 grammes (10–20 grains) should be taken three times a day or more often. It is important to find out when the urine is most alkaline and to give the acid sodium phosphate at the appropriate time. Each specimen of urine should be tested with red litmus paper or in cases of difficulty, the *p*H of the urine should be estimated. This procedure will enable the size and time of the dose or doses to be determined. If the patients with phosphaturia live in hot climates and sweat a great deal, an extra amount of fluid must also be taken to prevent the concentration of the urine.

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[1] WILLIAM ROBERTS. (1876), *Urinary and Renal Diseases*. Third edition, 299.

OXALURIA

In cases in which much oxalate of lime is separating out in the urine, one should select a diet which contains little oxalic acid and lime. Foods rich in oxalic acid should be avoided (e.g. spinach, rhubarb, etc. See pp. 131–2), and also those which contain much calcium (e.g. milk, eggs, fresh vegetables. See pp. 109–11), whilst the diet should consist of such foods as meat, cereals, bread, rice, peas, potatoes, apples, and coffee.

DIETETIC TREATMENT OF SCURVY

The history and present state of our knowledge has already been discussed (pp. 162–3), and it is only necessary here to mention the conditions under which especial care must be taken in order to prevent the occurrence of either scurvy or the sub-scurvy state. It is unnecessary to dilate on the care which should be taken in providing an adequate amount of vitamin C for those taking long sea journeys to the Arctic regions, etc. where fresh meat or fish is unobtainable, as these are so well known. In this country scurvy still occurs among infants who are fed on artificial foods (see p. 567) and it is essential to add to the diet sufficient orange- or lemon-juice to provide 25 milligrammes of ascorbic acid. If for any reason these disagree the ascorbic acid should be added to the milk in tablet form. Raw-meat juice does contain some ascorbic acid but should never be used because of the risk of conveying the eggs of intestinal parasites.

Frank scurvy is rare among adults but occurs among patients like old men who, living alone, do their own cooking or do not get fresh fruits (Bachelor's Scurvy). We feel that there is some danger in the present tendency to cook with gas obtained from a slot meter instead of with a coal-fire. Vegetables like cabbage which are a good source of ascorbic acid must be put in boiling water for 10 minutes (see p. 166). This is readily done over a coal-fire whereas in poor households the cost of gas for this purpose seems extravagant. Foods therefore tend to be fried and vegetables are not used. This does not really matter if plenty of fresh meat or some good fruit is eaten, but it is in these cases that either the cost is prohibitive or the patient has never learnt to eat it. Recent work has shown that many patients, and especially those being dieted for diseases of the alimentary tract, are in the sub-scurvy state, and frank scurvy may even occur. This is readily treated with orange-, lemon- or blackcurrant-juice, but if hæmorrhage from the stomach or intestines has taken place ascorbic acid, 300 milligrammes three times a day, should be given by mouth for two or four days (1800–3600 milligrammes), and thereafter a maintenance dose of 25 milligrammes a day.

The diet of patients, with either a wound or fracture or who are about to undergo operations, should always be enquired into and unless it is certain that the diet was adequate full doses of ascorbic acid should be given. For if, for some reason, the diet has been very freakish neither the wound nor bone will heal quickly, while abdominal wounds either of the stomach or skin may burst open.

Dietetic Treatment of Infantile Scurvy

The treatment of infantile scurvy is purely dietetic. Fresh milk contains so little vitamin C that it does not make any real difference whether the milk has been pasteurized, as it should be, or given as a dried powder. Under present conditions extra vitamin C should always be given. Scurvy is easily prevented by giving the juices of fruits which contain plenty of vitamin C ; e.g. " freshly " squeezed juice of oranges, lemons, grapefruits, swedes, or tomatoes, are all very valuable but if the fresh juice has been standing more than half an hour it will have deteriorated considerably. Fruit juice from a tin loses about half its vitamin C content in the process of preparation. See Food Tables, pp. 172–4.

The " war-time " products of rose-hip syrup or blackcurrant juice and purée are very useful, but the vitamin C content should be stated on the label. At least 25 milligrammes ascorbic acid should be given each day. In an emergency 100 milligrammes of ascorbic acid should be given for two or three days.

Treatment of Rickets and Diseases due to lack of Vitamin D

Rickets is due to several factors.

(1) The amount of vitamin D in the ordinary food is small. Milk in the summer contributes 57 I.U. per pint and butter 113 I.U. per 1 ounce, but the milk from the stall-fed cow in the winter contains very little, if any. The yolk of an egg in the summer may give 75 I.U. but 22 I.U. only in the winter. These amounts seem very small and help to explain why the disease is commoner in winter than summer.

(2) Vitamin D is believed to be made as the result of exposure of the skin not only to sunlight but also to indirect light when the sun is obscured by clouds (sky shine). The smoky atmosphere of some of the northern cities prevents this effect and is probably responsible for the prevalence of rickets in those cities. The

vitamin D is probably made from the sterols of the milk and other foods.

(3) A sufficiency of phosphorus and calcium must be supplied in the diet, and this will always be the case if the babies are given sufficient milk and later on cheese and an egg.

(4) Excess of cereal may be responsible and should be avoided. The use of patent foods containing much starch should be forbidden as they in some way upset the balance of the diet. Some cereals like oatmeal are more harmful than others as they contain excess of phytic acid which combines with the calcium and so prevents its absorption. Since the foods taken by babies and young children contain so little vitamin D and since they do not have the opportunity to make much vitamin D in the skin when they are brought up in large towns, it is necessary to give them extra supplies of the vitamin by mouth. This is administered in the form of liver oils which contain an adequate amount of vitamin D. The vitamin content of the oil should be clearly stated on the label. The British Pharmacopœa states that 1 drachm of oil should contain at least 300 I.U. of vitamin D, and 2000 I.U. of A. Cod-liver oil used to have a very unpleasant taste and unless a child was given it early he would often refuse to take it later on, and few adults will face it even now that it is relatively tasteless. The best oils, which are made from the liver which has been processed before decomposition of the liver has started, do not have an unpleasant taste. The synthetic product, calciferol, should be used if the patient dislikes the oil, but the cost is about ten times as great. It can be given as a tablet or dissolved in arachis oil as a liquid or in a gelatine capsule.

Vitamin A is often added to its preparations (see p. 701). Six drops of a good preparation usually contain 6000 I.U. of A and 1200 I.U. of D.

It is believed that the maintenance dose of vitamin D for a child of two should be at least 300–400 I.U. and that the curative dose is 1000–2000 units.[1] It may be much more in refractory cases.

In Older Children and Adults. Rickets may develop in young children after the age of two years if they suffer from cœliac disease. The patients pass a great deal of fat in the stool (steatorrhœa). Older patients also develop a similar disease, idiopathic steatorrhœa, and show changes in the bones similar to osteomalacia.[2] The condition is treated by ordering a diet containing the minimum amount of fat and giving vitamin D in the form of calciferol. For a child 5000–10,000 I.U. should be given daily, but an adult may require 10,000–20,000 I.U.

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[1] JEANS, P. C., and STEARN, G. (1938), *Journ. Amer. Med. Assoc.*, **111**, 703.

[2] BENNETT, T. I., HUNTER, D., VAUGHAN, J. (1932), *Quart. J. Med.*, **1**, (25), 603.

Rickets also develops in children of 4 to 12 or older who have a chronic kidney disease of moderate severity. Vitamin D is not of any value unless sufficient alkali is given by mouth to bring the alkali reserve within the limits of normal. When this is done, vitamin D in dose of 10,000–20,000 units cures the rickets.[1]

Hunger osteomalacia may occur in adults or older children as a result of long-continued undernutrition with a great deficiency of vitamin D in the diet. *Puerperal osteomalacia* occurs under similar conditions when the woman is pregnant. Both these diseases are readily cured when the deficiencies in protein, fat and calories are remedied and vitamin D in doses of 10,000–30,000 I.U. administered daily. This treatment relieves the symptoms and heals the bones very quickly.

Senile osteoporosis with fracture of the lumbar or lower thoracic vertebræ, but without any of the symptoms of osteomalacia, is a different disease of unknown causation.[2] A diet rich in calcium and phosphorus should be given and in addition calcium in the form of calcium phosphate 3 grammes a day and 6 grammes of sodium phosphate in the form of a powder. This will provide 1 gramme of calcium and 0·6 gramme of phosphorus. Vitamin D 5000–10,000 I.U. may be given at the same time to aid the absorption of the calcium and phosphorus from the gut, but the condition does not respond quickly like osteomalacia but improves very slowly.

It has been suggested that delay in the *healing of fractures* may be due to lack of vitamin D.[3] This is probably the case if the patient has taken a deficient diet for some time.

Very large doses, 750,000 I.U., were given by Tumulty and Howard[4] for 10–17 days in two patients respectively in the hopes of healing fractures more quickly. The patients developed nausea, vomiting and slight albuminuria with the presence of a few red cells and casts. The serum calcium rose to 15 and 18 milligrammes per 100 c.c. These unfavourable symptoms passed off quickly when the administration stopped, but the bones did not heal any quicker than usual. Small doses of 2000–5000 I.U. will aid the absorption of calcium and phosphorus from the gut and cannot do any harm.

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[1] Graham and Oakley. (1938), *Arch. Dis. Child.*, **1**, 1.

[2] Burrows, H. J., and Graham, G. (1945), *Quart. J. Med.*, in the Press.

[3] Nelson, C., F.V.R.C. (1941), *J. Amer. Med. Ass.*, 184.

[4] Tumulty, A. V., and Howard, J. F. (1942), *J. Amer. Med. Ass.*, **119**, 233.

3. *Diet in Disorders of the Stomach*

General Considerations

Seeing that the essential rôle of the stomach is a mechanical rather than a truly digestive one, the physical form of the food must always be of more importance in dyspepsia than its chemical composition. In proof of this, one finds that so long as the stomach is able to pass the food on into the intestine, absorption and nutrition go on without impairment, even although the digestive juices of the stomach itself are no longer present. The first rule to be observed, therefore, in drawing up a dietary for disorders of the stomach, is to see that the food is presented in such a form that the stomach has but little difficulty in driving it on into the duodenum. In practice this means that the food must be in a fine state of division, and should be carefully chewed.

The question of bulk must also be considered. The larger the mass of the food, the greater is the muscular labour imposed on the stomach. It is probably on this account that animal foods are, as a class, less troublesome to most dyspeptics than vegetable products. For the same reason, the meals in dyspepsia should be of small size, but taken at rather short intervals.

As regards the behaviour of the dyspeptic stomach to the different chemical ingredients of the food, great individual differences exist, and in no class of case is it more important to study the question of idiosyncrasy. In a majority of instances, however, one finds that fat is more apt to give offence than any other constituent. This is particularly true of *cooked* fat, possibly because in process of cooking fatty acids, acrolein, and other irritating substances, are apt to be liberated. On the other hand, butter and bacon-fat which have a low melting point can usually be managed with but little difficulty.

We may now pass to the more detailed consideration of the dietetic treatment suitable in different forms of gastric disorder, leaving the discussion of some further general principles until we come to speak of " functional " dyspepsias. In handling the subject it will be well to take up first those diseases of the stomach which are accompanied by definite organic change, and afterwards to consider the so-called " functional " disorders in one group. Such an arrangement is admittedly unscientific, but it has the advantage of practical convenience, and our knowledge does not at present admit of any more satisfactory system of classification.

GASTRIC ULCER

The principle is generally accepted in cases of gastric ulcer that the work of the stomach should be as light as possible and that the food should not irritate the mucous membrane. The idea of rest was carried so far at one time that no food was given by mouth and various types of nutrient enemata or water containing salt and sugar were given per rectum. It is now recognized that nutrient enemata are of very little value (p. 687) and they should not be used. Rectal salines are of great value when the patient has lost much fluid either by vomiting, severe hæmorrhage, or whenever the patient is unable for some reason to take a sufficient amount of fluid by mouth (p. 685). Under these conditions a 5 per cent. solution of glucose in tap water, $\frac{1}{5}$ normal saline, or $\frac{1}{5}$ Ringer's Solution is of great value, and 3000 c.c. may be given in the day if fluid is not given by any other route (for intravenous amino-acids, see p. 688).

Lenhartz[1] in 1906 introduced the practice of feeding patients by mouth, starting with very small amounts of an egg and milk mixture and gradually increasing it daily. The guiding principles of the diet were (1) to aid the healing of the ulcer by giving as much nourishing food as possible, (2) to fix the acid of the gastric juice by ensuring that the food contains a large proportion of protein, and so prevent its interfering with healing, (3) to lighten the work of the stomach as much as possible by the use of small feeds. It is often found that patients may vomit after a 6- or 8-oz. feed, but will not do so after 2-oz. feeds given at one- or two-hourly intervals. The details of the modified diet in use at St. Bartholomew's Hospital are as on page 625–6. Some physicians start at Diet 1 and increase the diet each day; but most of them start at Diet 4, 6, or 8, according to the severity of the symptoms, and increase every one or two days. If a patient has a return of pain while taking Diet 7 he is given Diet 6 or 5 for several days. When all symptoms have disappeared Diet 7 is again tried and if no evil symptoms occur the diet is increased every one, two, or three days. The patient should be kept on Diet 12 until all the symptoms have subsided, the stools do not contain any blood by chemical tests, the X-ray after a barium meal is normal and an ulcer cannot be seen with the gastroscope.

***Suggested Details for Diet* 9.**

All liquid feeds should be 5 oz. ($\frac{1}{4}$ pint or a small breakfast-cupful).

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[1] LENHARTZ. (1907). *Med. Klin.*; LANGDON BROWN. (1908). *Clin. Journ.*, **33**, 109.

One teaspoonful of sugar should be added to each feed. Take nothing except the foods and amounts given below.

7 a.m. Boiled fresh milk and water (equal parts), or dried milk watered down to half the strength given on the packet.
1 Rusk or cream cracker.
9 a.m. 1 Egg beaten up in milk.
11 a.m. Boiled fresh milk and water (equal parts), or dried milk, Benger's Food, or alternatives watered down to half strength.
1 Rusk or cream cracker.
1 p.m. Boiled or steamed white fish, 2 oz. (3 level tablespoonfuls). White sauce or milk to moisten if desired. No salt, seasoning, or parsley.
Blancmange, custard, or junket, 2 oz. (2 level tablespoonfuls).
3 p.m. Boiled fresh milk and water (equal parts) or dried milk, Horlick's Malted Milk, or alternatives watered down to half strength.
1 Rusk or cream cracker.
5 p.m. 1 Egg beaten up in milk.
1 Rusk or cream cracker.
7 p.m. Boiled fresh milk and water (equal parts), or dried milk, Ovaltine, Bournvita, or alternatives, watered down to half strength.
Blancmange or custard or junket, 2 oz.
9 p.m. 1 Egg beaten up in milk.
11 p.m. Boiled fresh milk and water (equal parts), or dried milk watered down to half strength.

During the night, when awake, take 5 oz. boiled fresh milk and water (equal parts), or dried milk watered down to half strength.

Water, up to 5 oz., may be taken between any two feeds, and the juice of one orange well strained once in the day, if allowed by the doctor.

Any fruit juice like lemon, grape-fruit, tomato, blackcurrant and rose-hip syrup can be taken to vary the taste of the food.

Suggested Details for Diet 14.

All liquid feeds should be 5 oz. (¼ pint or a small breakfast-cupful). One teaspoonful of sugar should be added to each feed. Take nothing except the foods and amounts given below.

7 a.m. Boiled fresh milk and water (equal parts), or dried milk watered down to half the strength given on the packet.
2 Buttered rusks or cream crackers.
9 a.m. 1 Egg beaten up in milk.
2 Buttered rusks or cream crackers.

Diet	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Eggs	1	1	2	3	3	3	4	4	3	3	3	2	2	2
Milk, beaten up with eggs . oz.	3	6	6	7	9	12	12	17	9	9	9	6	6	6
Milk and egg, given at a feed . oz.	1	1½	2	2½	3	3½	4	5	5	5	5	5	5	5
Boiled fresh milk and water (equal parts), or dried milk watered down to half the strength given on the packet, at a feed . . . . . oz.	1	1½	2	2½	3	3½	4	5	5	5	5	5	5	5
Sugar, in each feed . . teasps.			½	½	½	1	1	1	1	1	1	1	1	1
Blancmange or custard or junket oz.								4	4	7	7	10	10	10
Cream crackers or rusks . no.									4	6	8	10	12	16
Boiled or steamed white fish oz.									2	2	2	2	2	2
Butter . . . . oz.										¾	1	1½	1½	1½
Milk, total amount required for fluid feeds per day . . oz.	5½	10	11	13½	16½	21	22	29½	24	24	24	23½	23½	23½
Calorie value approximately .	186	276	517	643	703	938	1034	1340	1318	1679	1807	2024	2094	2234

Feeds to be taken two-hourly by day and four-hourly by night.
Milk and egg feeds and milk and water feeds to be taken alternately.
Two to four oz. of water or one-third strength normal saline should be given between the feeds.
Whole milk can be given instead of milk diluted with water.
Two oz. of orange-juice a day.
N.B.—A fluid oz. = 2 tablespoonfuls; 5 oz. = ¼ pint; 10 oz. = ½ pint; 20 oz. = 1 pint.

11 a.m. Boiled fresh milk and water (equal parts), or dried milk, Benger's Food, or alternatives watered down to half strength.
2 Buttered rusks, cream crackers or plain biscuits.

1 p.m. Boiled or steamed white fish, 2 oz. (3 level tablespoonfuls). White sauce or milk to moisten if desired. No salt, seasoning or parsley.
Blancmange, custard or junket, 5 oz. (¼ pint or 5 level tablespoonfuls).
1 Buttered rusk, cream cracker or ½ oz. of bread and butter.

3 p.m. Boiled fresh milk and water (equal parts), or dried milk, Horlick's Malted Milk, or alternatives watered down to half strength.
2 Buttered risks, cream crackers or plain biscuits.

5 p.m. 1 Egg beaten up in milk.
2 Buttered rusks, cream crackers or ½ oz. of bread and butter.

7 p.m. Boiled fresh milk and water (equal parts) or dried milk, Ovaltine, Bournvita, or alternatives watered down to half strength.
Blancmange, custard, or junket, 5 oz. (¼ pint or 5 level tablespoonfuls).
2 Buttered rusks, cream crackers or plain biscuits.

9 p.m. Boiled fresh milk and water (equal parts), or dried milk or alternatives watered down to half strength.
2 Buttered rusks, cream crackers or ½ oz. of bread and butter.

11 p.m. Boiled fresh milk and water (equal parts), or dried milk or alternatives watered down to half strength.

During the night, when awake, take 5 oz. boiled fresh milk and water (equal parts), or dried milk, watered down to half strength, and 1 rusk or cream cracker.

Water up to 5 oz. may be taken between any two feeds, and the juice of one orange well strained once in the day, if allowed by the doctor.

If a patient dislikes or cannot take eggs, a cream or mild cheese can be substituted. Extra protein can also be given in the form of shapes made of dried milk flavoured to taste.

A similar diet is that introduced by ***Sippy.***

"Three oz. of a mixture of equal parts of milk and cream are given every hour from 7 a.m. to 7 p.m. After one or two days, a soft egg with cracker or bread and butter may be added to one of the forenoon feedings; 3 oz. of a cereal, such as well-cooked rice, oatmeal, or farina, may be added to one of the afternoon feedings. The cereal is measured after it is prepared. Gradually egg and cereal are added until at the end of the first week the patient usually is taking each day 3 oz. of the milk-and-cream mixture every hour from 7 a.m. until 7 p.m., and in addition two or three soft eggs, one at a time, and 6 to 9 oz. of a cereal, 3 oz. at one feeding. The cereal and egg are given alternatingly, and at the time and in addition to the 3-oz. mixture

Feeds by Day.	Food.	Diets.		
		1.	2.	3.
1.	Whole milk (fresh or dried) oz.	5	5	5
	Patent barley or strained porridge	Portion	Portion	Portion
2.	1 Egg beaten up in milk oz.	5	5	5
	Buttered rusks or cream crackers	—	1	2
3.	Whole milk (fresh or dried) oz.	5	5	5
	Marmite to taste			
	Barley sugar oz.	1	1	1
	Thin crustless white bread and butter slices	—	1	2
4.	Strained orange- or tomato-juice oz.	1	1	1
	Vegetable purée (see list)	Portion	Portion	Portion
	Pudding (see list)	,,	,,	,,
	Cream oz.	1	1	1
	Boiled or steamed fish	—	—	Portion
5.	1 Egg beaten up in milk oz.	5	5	5
	Barley sugar oz.	1	1	1
	Buttered rusks or cream crackers	—	1	2
6.	Whole milk (fresh or dried) oz.	5	5	5
	Fruit purée (see list)	Portion	Portion	Portion
	Pudding (see list)	,,	,,	,,
	Cream oz.	—	1	1
	Thin crustless white bread and butter slices	—	1	2
7.	1 Egg beaten up in milk oz.	5	5	5
	Black treacle or barley sugar oz.	1	1	1
	Buttered rusks or cream crackers	—	1	2
8.	Whole milk (fresh or dried) oz.	5	5	5
	Fruit purée (see list)	Portion	Portion	Portion
	Pudding (see list)	,,	,,	,,
Feeds at Night (when awake)	1. Whole milk (fresh or dried) oz.	5	5	5
	2. 1 Egg beaten up in milk oz.	5	5	5
Between Feeds	Strained orange- or tomato-juice oz.	1	1	1
	Water up to 5 oz. when desired			
	Approximate caloric value	2545	3118	3624

of milk and cream. Custards, cream, soups, vegetable purées, and other soft palatable foods may be substituted now and then for the milk-and-cream feedings. Jellies and marmalades may be gradually added if desired. The patient should be weighed. If desired, a sufficient quantity of food may be given to cause a gain of 2 or 3 lb. each week. . . .

"At the end of three weeks of the treatment, three small meals, none of which exceeds 10 to 15 oz. in total bulk, are substituted for three of the feeds, the remainder of which are continued as before. These meals are made up of vegetable purées, potatoes, and cooked fruits. Bacon and meat broths are added. . . .

"Upon resuming normal activity or work, the patient continues the same management. He eats the three small meals at home, or wherever it may be convenient. Milk and cream mixed, equal parts, is taken with him to his place of business. A thermos bottle is a desirable container. From this supply a flat flask may be filled and carried in the pocket."

Meulengracht [1] has found that patients with hæmatemesis have a lower mortality if they are given a fair amount of food very soon after the hæmatemesis. Witts,[2] who modified this diet to meet English tastes, has also had good results. (See p. 628)

Diet I does not differ materially in composition from the 8th Lenhartz Diet, but its caloric value is much higher owing to whole milk being given instead of milk diluted with water, and to the addition of extra sugar and cream. The vitamin C content is slightly higher owing to the use of the purées of vegetables and fruit instead of only orange-juice. The Caloric value of Diet 3, 3624 Calories, seems higher than is necessary for patients doing an average amount of work, though it may be indicated if the patient has lost a great deal of weight or has returned to hard work.

These diets differ from the early stages of the Lenhartz Diet in that they contain in addition to the greater Caloric value much more fluid, which is of use when the patients have had a hæmatemesis. The water can be added to the Lenhartz Diet in the form of quarter strength normal saline, and adequate amounts should be given.

Both the Lenhartz and Sippy Diets in their original form contained very little ascorbic acid as all vegetables were omitted and the juice of oranges and lemons was forbidden because they have an acid taste.[3] It has been found (Harris and Ray,[4] Archer and

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[1] MEULENGRACHT. (1934), *Acta Med. Scand.*, **59**, 374.

[2] WITTS, L. J. (1937), *Brit. Med. Journ.*, **1**, 847.

[3] Meulengracht's Diet contains 30–50 milligrammes of ascorbic acid.

[4] HARRIS, L. J., RAY, S. N., and WARD, A. (1933), **27**, 2011; HARRIS, L. J., ABBASY, M. A., YUDKIN, K., and KELLY, S. (1936), *Lancet*, **1**, 1488.

Graham,[1] Portnoy and Wilkinson,[2] etc.), that patients fed on these diets are in the sub-scurvy state and the degree of deficiency is especially great when patients have suffered from a hæmatemesis. Most patients have had symptoms of dyspepsia some time before they seek medical aid, and it may be assumed that they have omitted from their diet the common sources of ascorbic acid. It was recommended (Archer and Graham) that 1000 milligrammes of ascorbic acid should be given each day for three days to all patients with symptoms of gastric ulcer, and for four days if a hæmatemesis has occurred. Thereafter a maintenance dose of 25–50 milligrammes should be given daily either in the form of orange- or lemon-juice, blackcurrant purée or syrup, or hip and haw syrup or as pure ascorbic acid.

The after-treatment is very important if the ulcer is to heal soundly. Alcohol should not be allowed as it is liable to cause or keep up a gastritis. The use of foods highly seasoned with mustard, pepper, spices, and condiments of all kinds should be forbidden for the same reason. Tea and coffee should either be forbidden or only allowed if well diluted with water or milk. Cane-sugar should not be given because it causes a large secretion of mucus ; glucose and lactose are said to do less harm.

The smoking of all kinds of tobacco should be forbidden. The evil effect of tobacco is probably due to the nicotine and its decomposition products, e.g. pyridine, being dissolved in the saliva and so swallowed. The taste of the saliva of a heavy smoker can be best appreciated by a non-smoker if, when working in a laboratory, he uses the distilled-water wash bottle of the smoker. Many patients find great difficulty in giving up smoking.

Jejunal Feeding

If the ulcer is very large or heals very slowly resort may be had to jejunal feeding. This is said to be better than duodenal feeding as the meal sometimes regurgitates from the duodenum into the stomach and details of jejunal feeding alone are given.[3]

A soft pliable Einhorn's tube is passed into the stomach and after the tip has passed the pylorus it is pushed onwards until the tip is 32 in. to 35 in. from the lips. The initial feeds should consist of 1 raw egg beaten up, 150 c.c. (5 oz.) milk and 15 grammes ($\frac{1}{2}$ oz.) lactose. This is strained through several layers of gauze warmed to a temperature of 100° F.; placed in a receiver 4 in. above the upper surface of the abdomen. The size of each feed is increased by 10 c.c. ($\frac{1}{3}$ oz.) each day until 210–240 c.c. are administered. The tube is left in position and washed through after each feed with normal saline and air. Extra fluid is given on the second day in the form of 350 c.c. of one-third normal saline twice a day and the volume is increased up to 750 c.c. b.d. 100 milligrammes ascorbic acid should be given daily.

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[1] Archer, H. E., and Graham, G. (1936), *Lancet*, **2**, 364.

[2] Portnoy, B., and Wilkinson, J. F. (1938), *Brit. Med. Journ.*, **1**, 553.

[3] Bockus. (1924), *J.A.M.A.*, **82**, 351.

An alkaline powder consisting of magnesium oxide gr. 3., bismuth subnitrate gr. 15., water to 1 oz. is given by mouth between feeds and a double dose at night so as to ensure that the stomach mucosa is always alkaline.

The tube is removed after two weeks and a modified Sippy diet is given for the next two weeks.

Modified Sippy Diet

		8 oz. Milk.
		1 Egg.
	with	8 oz. malted milk.
4–7th day.		3 oz. Cooked cereal, for three feeds.
		Biscuits and butter.
8–15th day.	8 a.m.	2 Soft boiled eggs.
		Toast and butter.
		Cooked cereal.
		1 glass milk.
	10 a.m.	Egg and milk.
		Biscuit and butter.
	Dinner.	Fish or sweetbread.
		Purée of vegetables.
		Mashed potatoes.
		Tapioca pudding.
	4 p.m.	Malted milk.
	Supper.	Clear soup.
		Poached egg.
		Chicken or lamb chop.
		Purée and mashed potatoes.
		Bread and butter.
		Cocoa and milk.
	9 p.m.	Egg and milk.

50 milligrammes ascorbic acid should be given daily.

A jejunostomy is sometimes performed if patients with severe gastric diseases suffer from uncontrollable vomiting, alkalosis and renal failure which cannot be controlled by intravenous therapy. The patients must be fed by this route for some weeks. The indwelling catheter must be size 17 or greater.

Scott and Ivy have been able to keep dogs alive and well with the following mixture which Colp and Druickerman[1] have used with success on men.

Four hours after the jejunostomy 60 c.c. of warm normal saline are given every 2 hours. After 12 hours 60 c.c. (2 oz.) of the Scott-Ivy pabulum is given every 2 hours alternately with 60 c.c. (2 oz.) saline. The quantity of the feed is gradually increased to 120 c.c. (4 oz.)

If the ulcer does not heal after a good trial has been given to these various measures a partial gastrectomy should be considered.

Scott-Ivy Pabulum.[2] Sugar 150 grammes, water 3000 c.c. Add peptone 100 grammes and wait till it dissolves. Heat to 60° C. for a few minutes and add it to 300 grammes of wheat flour making a paste at first and then diluting it with all the peptone and sugar. Then add 2000 c.c. milk mixed with 1000 c.c. cream 20 per cent. and bring to a boil quickly, stirring vigorously, but do not allow to boil. Maintain just below the boiling point until it thickens to the consistency of a thick cream soup. Cool and place in a refrigerator where it will keep for 4–5 days.

100 c.c. contains	Protein	3·5	= 85 calories.
	Carbohydrate	8·1	
	Fat	4·3	
	Add 10 c.c. emulsified bile.		
Vitamins.	Vitamin A	3000 I.U.	
	,, D	600 I.U.	
	(as Radiostoleum)	3 drops or Adexolin.	
	Vitamin B_1	1000 I.U., 3 mg.	
	Riboflavine	1 mg.	
	Nicotinamide	50 mg.	
	Vitamin C	10 mg.	

DIETS IN CONVALESCENCE FROM ACUTE DYSPEPSIA

The series of Diets Nos. 1, 2, and 3 in use at St. Bartholomew's Hospital are useful for convalescence, and if a patient can take Diet 3 without any symptoms he may then begin to return to an unrestricted diet. He should understand that as soon as any symptoms return he should use the convalescent Diet 1, and if the symptoms continue should use a lower stage of diet, say the 6th or 8th Lenhartz Diet or Meulengracht 1st diet.

DIET I. Eight feeds should be taken during the day, the first on waking; milk and biscuits should be taken during the night whenever the patient wakes. The four main meals which are given below, should be equal in size. The small feeds given between meals at two-hourly intervals. These *between feeds* should consist of: ¼ pint of warm boiled milk, flavoured if desired with cocoa, Bournvita, Ovaltine, Marmite, Horlick's, Benger's, or the like. Cream crackers, rusks, or other plain biscuits, not wholemeal. If the beverage and biscuits cannot be obtained, one or other will suffice, and should neither be obtainable a piece of plain or milk chocolate may be eaten slowly.

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[1] COLP, R., and DRUICKERMAN, L. J. (1943), *Ann. of Surgery*, **117**, 387.

[2] SCOTT, H. G., and IVY, A. C. (1931), *Ann. of Surgery*, **93**, 1197.

Water (not iced) up to ¼ pint may be taken between feeds, and a small amount with meals.

The well-strained juice of an orange must be taken twice daily, preferably between feeds. Fresh-strained tomato-juice may be substituted occasionally, or a glass of tinned tomato-juice, or black-currant juice or purée, or hip and haw syrup. In cases where fruit juices are not tolerated, one or two tablets of ascorbic acid (25–50 milligrammes) may be substituted.

Food should be cooked with a little salt, but no other condiments.

DIET II. If desired the number of feeds may be reduced to seven, and the interval between them increased to two and a half hours. The main meals should be somewhat bigger than the between feeds.

DIET III. This is an easily digested normal diet suitable for constant use by patients who have suffered from gastric or duodenal ulcer or other continued gastric disturbance. The interval between meals may be increased to three or four hours, and the number reduced to four or five. The main meals should be of normal, medium size. If the patient ought to gain weight, three or four "between" feeds should be given. They should also be given if any discomfort is felt in the interval between meals.

DIET III ADAPTED FOR ACHLORHYDRIA. No between feeds should be taken. Only small amounts of fluid should be taken with meals, the rest being drunk between them. Each meal should be begun with a mild appetizer such as tomato, orange, or grapefruit juice, or a small teacupful of Marmite. The latter should be taken daily as a beverage or sandwich spread.

DIET I

BREAKFAST.

One egg, lightly boiled or poached.

White bread, stale and crustless, cut thinly, or crisp toast (not hot), with butter.

Honey, golden syrup, apple, black currant, or bramble jellies, or strained jelly marmalade.

Weak tea or cocoa with plenty of milk. Sugar if desired.

DINNER.

Fresh white fish, boiled or steamed, or stewed sweetbreads, brains or tripe.

Plain white sauce if desired.

Mashed old potatoes or crustless stale white bread, cut thinly, or plain biscuits.

Milk pudding, custard, junket, blancmange, jelly, or plain steamed cake-mixture pudding.

TEA.

White bread or toast and butter as at breakfast.

Honey, etc., as at breakfast, or Marmite.

Plain sponge or Madeira cake or biscuits.

SUPPER OR LUNCH.

One or two eggs lightly boiled or poached, or fresh cream or milk cheese.

Cream crackers, rusks, or other plain biscuits.

Warm boiled milk, if desired, flavoured with cocoa, Bournvita, Ovaltine, Benger's, Horlicks, or the like.

Pudding as at dinner, if desired.

Interval between meals and feeds, two hours.

Not allowed.

Beer, stout, whisky, and other alcoholic drinks, and mineral waters (except soda-water).

Brown bread, new white bread, rolls, buns, porridge, and digestive, wholemeal, ginger, coco-nut, Vitaweat, or Ryvita biscuits.

Coffee.

Fish with fine bones, such as herrings, or salt fish and salmon.

Fried foods of all kinds.

Fruit stewed, tinned, or raw (except strained orange-juice).

Jam, peel of marmalade, currants, and other dried fruit, nuts, seeds.

Meat, bacon, ham, sausages, chicken and rabbit.

Pickles and rich sauces, vinegar, condiments, added salt, or other seasoning.

Soups, meat extracts, and Marmite.

Suet puddings and pastry.

Vegetables and salads of all kinds, and parsley in sauce.

Smoking.

DIET II

BREAKFAST.

The same as in Diet I.

DINNER.

As Diet I, with the following additional alternatives:

Boiled or roast chicken or guinea fowl (no skin or gristle) or stewed rabbit.

Flower of cauliflower, sieved carrots, spinach, peas or tomatoes.

Baked or stewed apple (no skin or core), sieved stewed prunes, apricots, peaches or pears, fresh or tinned, or sieved raw bananas.

TEA.

The same as Diet I.

SUPPER OR LUNCH.

The same as Diet I.

Interval between meals and feeds, two to two and a half hours.

Not allowed.

Beer, stout, whisky, and other alcoholic drinks, and mineral waters (except soda-water).

Brown bread, new white bread, rolls, buns, porridge, and digestive, wholemeal, ginger, coco-nut, Vitaweat, or Ryvita biscuits.

Coffee.

Fish with fine bones, such as herrings, or salt fish and salmon.

Fried foods of all kinds.

Fruit (except those given above).

Jam, peel of marmalade, currants, and other dried fruit, nuts and seeds.

Meats such as bacon, beef, ham, sausages, brawn.

Pickles, rich sauces, vinegar, and condiments, except salt in small quantities.

Soups, meat extracts, and Marmite.

Suet puddings and pastry.

Vegetables (except those given above), new potatoes, parsley, and salads.

Smoking.

DIET III

BREAKFAST.

As Diets I and II with the following additional alternatives:

Finely ground brown bread.

Fresh white fish, steamed or grilled, or a second egg.

The eggs may be scrambled.

DINNER.

As Diet II with the following additional alternatives:

Tender lamb or mutton, veal, liver, tongue, or ham.

Grapes, soft ripe plums, pears, and peaches, avoiding skin, pips, and stringy portions.

Boiled old potatoes.

Vegetables and fruit in Diet II need not be sieved.

TEA.

As Diets I and II with the following additional alternatives :
Finely ground brown bread.
Plum or apricot jam.

SUPPER OR LUNCH.

As Diets I and II with the following additional alternatives :
Steamed or grilled fresh white fish, chicken, etc., as at dinner.
Vegetables and fruit as at dinner.
Interval between meals and feeds, three to four hours.

Not allowed.

Beer, stout, whisky, and other alcoholic drinks, and mineral waters (except soda-water).
Coffee.
Fried foods.
Fruit skins, seeds, and hard fruits such as raw apple, pineapple, etc., dried fruits, and nuts.
Kippers, bloaters, and salmon.
Meats such as beef, and the tough parts of all other meats.
Meat soups, meat extracts, and Marmite.
Pickles, rich sauces, vinegar, and condiments, except salt in moderate amounts.
Suet puddings and pastry.
Vegetables such as cabbage and onions, also the stalks, skins, pips, and hard fibrous parts of other vegetables.

ACUTE AND CHRONIC GASTRITIS

The disease may start with vomiting, and this may be so severe that even 1-oz. feeds of milk are rejected. In this case fluid should be given per rectum either as a 5 or 6 per cent. solution of glucose in tap water or $\frac{1}{4}$ or $\frac{1}{5}$ normal physiological saline or Ringer's Solution. 600 c.c. (1 pint) may be given 4-hourly or in the form of a continuous drip, 3000 c.c. a day (5 pints). When the gastritis is severe it may be accompanied by an acute enteritis, which renders the giving of fluid per rectum impossible. In these cases the fluid should be given intravenously or intramuscularly, either as a continuous drip of 5 per cent. glucose in $\frac{1}{4}$ or $\frac{1}{5}$ normal saline or Ringer's Solution, or 600 c.c. may be given three to four times a day (p. 687). When the acute condition either improves sufficiently for the patient to be fed by mouth or is not severe enough to cause vomiting the early stages of the Lenhartz or Sippy diets should be used. It is usually possible to increase the diets much more quickly than if an ulcer is present.

In the treatment of chronic gastritis the condition will usually improve quickly with the full diet allowed by Lenhartz and Sippy or Meulengracht, but it may be necessary to order a diet like the

6th or 8th Lenhartz Diet. When the symptoms disappear the diet can, as a rule, be increased more quickly than in the treatment of gastric ulcer.

ALCOHOLIC GASTRITIS

It is essential that all alcohol should be given up even if the patient says that alcohol is the only thing which enables him to eat a meal. If vomiting is a prominent feature the patient should be in bed and small divided meals should be given, say Lenhartz Diet 8 or 10. The diet can be increased fairly quickly as soon as the ill effects of the alcohol have passed away.

DILATATION OF THE STOMACH

Complete Pyloric Obstruction. When the diagnosis has been made fluid should not be given by mouth as it cannot pass the pylorus. At least 3000 c.c. of fluid should be given either per rectum or intravenously or intramuscularly or by sternal puncture. (p. 685). It is essential to give large amounts of ascorbic acid as Payne [1] showed that in 12 out of 51 cases, peritonitis was a serious complication after any operation on the stomach, and that the wounds showed no sign of healing. Archer and Graham [2] suggested that this was due to a lack of ascorbic acid. They recommended that at least 3000 milligrammes should be given before any operation.

The patients are usually in the sub-scurvy state and it is important to give at least 3000 milligrammes of ascorbic acid. If the pyloric obstruction is severe it is necessary to give it intramuscularly.

If large doses of ascorbic acid are given intravenously some will be excreted in the urine and suggest that the patient was not in the sub-scurvy state. One of us (G. G.) has found that 300 milligrammes can be given intravenously twice a day without causing much loss of ascorbic acid in the urine. If this amount is given for five days the risk of the wounds failing to heal is very small, but it is advisable to give a daily dose of 1000 milligrammes of ascorbic acid for the first three days after the operation.

Partial Obstruction. It is often uncertain whether the dilatation of the stomach is due to an organic obstruction or to an atony of the walls of the stomach. The food should consist of milk, egg and milk, or milk and cream, or other substances which will pass through the pylorus easily. About 200 grammes of glucose should be added to the feeds during the day. Two or three ounces of the mixture should be given every one or two hours during the day. A stomach tube should be passed two or three hours after the last meal, say at 9 or 10 p.m. The contents should be withdrawn with the aid of a Senoran's bottle, and should be measured. The stomach should then be washed out with water once or twice and completely emptied. Finally, 200 c.c. (7 oz.) of a 2 per cent. solution of normal physiological saline (4 grammes NaCl) should be passed down the tube so as to prevent the patient suffering from lack of sodium chloride. If large amounts of fluid are recovered each night, some fluid should be given per rectum so as to prevent the patient from suffering from loss of fluid. A good idea of the progress of the case can be gained by the amount of fluid withdrawn each night.

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[1] PAYNE, R. T. (1936), *St. Bart's Hosp. Reports*, **69**, 191.

[2] ARCHER, H. E., and GRAHAM, G. (1936), *Lancet*, **11**, 364.

If the amount recovered each night shows no decrease in about two weeks it is probable that the dilatation is due to an organic stricture. If the dilatation was due to atony of the muscles these may regain their tone with the rest and the amount of fluid removed each night will get less and less. If this occurs the diet can be increased but the amount of fluid which is given should be small, say 1200 c.c. (1½ pints) and a diet suitable for flatulent dyspepsia is of value (p. 642).

Ascorbic acid should be given in the same dosage as for patients with complete obstruction. It may be necessary to give it intramuscularly if much fluid is removed each night, as none of the ascorbic acid may be absorbed.

Non-obstructive (Atonic Dilatation). In cases of atonic dilatation the diet should be the same as for flatulent dyspepsia (*q.v.*).

FUNCTIONAL DYSPEPSIAS

Under this heading one may group for convenience that large and heterogeneous class of cases in which digestion is performed painfully or with difficulty, but in which no organic change in the organs of digestion can be discovered. In some of these cases the chemistry of the stomach is at fault, in more there is a disorder of motility, but in some there may be a hyperæsthesia of the stomach, an undue sensitiveness to normal irritants.

In treating them it is essential to keep one or two principles clearly before one's mind. (1) Every effort should be made to discover the cause of the condition and to exclude the presence of other disease. (2) In many of these cases the patient's general nutrition requires to be considered rather than his mere gastric sensations. If the nervous system and blood can be raised to a proper level of health, the dyspeptic symptoms often disappear spontaneously. For this reason great harm may be done by too strict dieting. The tendency in such patients is to go on cutting off one article of food after another until a state of semi-starvation is induced, in which it is impossible for any organ in the body properly to perform its work. Instead of adopting this plan, it would be well if such patients could be induced to follow the advice of King-Chambers, and add to the diet any article of food that had once been found to agree, rather than to cut out of it anything that had ever disagreed. (3) Mental and physical rest, preferably in bed, is a great and sometimes indispensable aid to treatment. It acts both by economizing vascular and nervous energy and by enabling nutrition to be efficiently carried out upon a minimum quantity of food, and therefore with the least amount of labour on the part of the digestive organs. (4) In no class of gastric disorders does the question of idiosyncrasy play a greater part than in this. Due regard must therefore always be paid to the inclinations of individual patients in arranging the diet-sheet.

In all cases of this class, the same elementary dietetic rules must be observed as in other forms of digestive trouble. The food must be in a suitable physical form, all notoriously indigestible articles being avoided ; the meals should be properly arranged, and chewing carefully performed. To these simple directions one need only add that good cooking and attractive presentation of the meals are here of the first importance.

In all cases the most easily-digested foods should be selected, these being

(*a*) Meats : Mutton, venison, sweetbreads, chicken, tripe, rabbit, grouse, partridge, pheasant.
(*b*) Fish : Whiting, sole, turbot.
(*c*) Farinaceous foods : Stale white bread, rusks, plain biscuits, rice, tapioca, sago, arrowroot.
(*d*) Vegetables : Asparagus, sea-kale, spinach, cauliflower, French beans.
(*e*) Fruits : Baked apples, or the juice of oranges or grapes.

"Made dishes," twice-cooked meats, sauces, pastry, pickles, cheese, sweets and preserves should be avoided altogether. Meat should be slightly underdone; fish should be boiled or steamed, or if it is deep fried, the batter coating should not be eaten.

The special rules of diet will depend upon the particular form of dyspepsia with which one has to deal. For practical purposes one may distinguish the following varieties :

1. Defective secretion (hypochlorhydria, achlorhydria and achylia).
2. Excessive secretion (hyperchlorhydria).
3. Defective motility ("atonic" dyspepsia).
4. Excessive sensibility (gastralgia).

The principles to be observed in prescribing rules of diet in each of these forms may now be briefly discussed.

1. ***Defective Secretion.*** There may be no symptoms of dyspepsia in patients with hypochlorhydria or complete achlorhydria, and if so dietetic regulations are not required. Some of these patients have pain and discomfort immediately after the meal is taken and examination of the gastric contents and with X-rays show that the stomach empties very quickly. The foods should either be pounded, minced or sieved, so as to ensure the food being finely divided when it reaches the intestines. In mild cases, thorough mastication of the meat, etc., may suffice. The rapid passage of the food may be reduced or prevented by giving fatty foods with the meals, or an oil like olive or almond after the meal has started.[1]

DIRECTIONS FOR DIET IN ACHLORHYDRIA.

1. The diet should contain the usual amount of eggs, milk, cheese, fish and meat. (The latter two may have to be pounded or minced.)
2. Salt, pepper, mustard, meat extract, marmite, gravies, meat soup, spices, pickles, condiments, are allowed in normal amounts.
3. Bread, potatoes are allowed.
4. Orange- or lemon-juice, 4 oz., or other fresh fruit should be taken once or twice a day. If these disagree, 25 milligrammes of ascorbic acid should be given each day.
5. Fluid should not be taken at meals though one glass of wine, red or white, is allowed.
6. Hydrochloric acid, minims 15, may be taken in 3 oz. of water with the meals.
7. Sufficient fluid should be taken either half an hour before meals or two hours after meals to relieve thirst or any discomfort from lack of fluid. At least two to three pints of fluid should be taken daily.

2. ***Excessive Secretion.*** Much discussion has taken place as to whether the diet in cases of hypersecretion should be mainly animal or vegetable in constitution.[2] On the one hand, there is no doubt that an animal diet "fixes" the excess of hydrochloric acid most efficiently, whilst on the other there is abundant evidence to show that in the long-run a mainly vegetable diet leads to a permanent diminution of acid formation. An animal diet is therefore the best palliative, whilst a vegetable diet is more strictly

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[1] MORRELL ROBERTS. (1931), *Quart. Journ. Med.*, **24**, 133.

[2] See SCHLOSS, (1907), "Vegetabilische oder Fleischnahrung bei Hyperacidität" (*Arch. f. Verdauungs Krankh.*, **13**, 233).

curative in effect. In the experience of Hutchison a predominatingly animal diet gave the best results, whilst other means may be relied upon for actually lessening secretion (e.g. the free use of fats, administration of alkalies, etc.).

On the other hand, it is reasonable to exclude all direct stimulants of secretion. Under this heading come such substances as common salt, extractives of meat, the various condiments, and alcoholic beverages.

There is both experimental and clinical evidence[1] to show that fats have a restraining influence on gastric secretion.

The evidence[1] suggests that the unsaturated oils like linseed and cod-liver oil are the most effective. These are unpleasant to take and olive or almond oil, which are less effective, are used. The oil produces the greatest effect when it has entered the duodenum before the meal is taken. The usual dose is one ounce.

Foods rich in carbohydrates, on the other hand, must be eaten sparingly, as free acid appears in the stomach very early after their use, and the conversion of their starch by the saliva is interfered with. For this reason the addition of malt to farinaceous foods is often of great service in cases of hyperacidity. It stands to reason that where "acidity" of the stomach is proved, all sour articles should be banished from the diet. Vinegar and some wines are examples in point.

The application of the above principles may be expressed in the following rules:

DIRECTIONS FOR DIET IN HYPERCHLORHYDRIA.

1. The diet should consist mainly of animal constituents (eggs, milk, cheese, fish, and meat).
2. Green and root vegetables may be eaten in moderation unless flatulence occurs.
3. Salt, pepper, mustard, meat extracts, gravies, meat soups, spices pickles and condiments should be altogether avoided.
4. Bread and potatoes should be taken very sparingly, but bacon and butter may be eaten freely.
5. Sugar and all sweet or sour things should not be eaten.
6. Orange- or lemon-juice, 4 oz., or other fresh fruit should be taken once or twice a day. If these disagree, 25 milligrammes of ascorbic acid should be given each day.
7. Alcoholic beverages should be avoided. The best drink at meals is an alkaline water such as Apollinaris or Perrier.
8. One ounce of olive or almond oil should be taken 10 minutes before meals.

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[1] MORRELL ROBERTS. (1931), *Quart. Journ. Med.*, 133.

3. *Defective Motility* (Atonic or Flatulent Dyspepsia). In this form of dyspepsia the mechanical form of the food, as in cases of defective secretion, is of chief importance. It is essential to avoid burdening the stomach with large quantities of material, especially such as is of a bulky sort (e.g. green vegetables). The simultaneous presence in the stomach of solids and liquids is specially injurious, for in such circumstances the fluid part of the meal is retained for a long time in the organ, and tends to dilate it by its mere weight. The meals should therefore be dry, and care should be taken not to drink for at least two hours after solid food has been taken.

If flatulence[1] is much complained of—as it often is—green vegetables, peas and beans should be avoided altogether, on account of their "windy" tendency, and the starchy foods should be strictly limited. The necessity for reducing the starches in flatulence is a principle derived from experience for which it is difficult to find a satisfactory reason. It certainly does not reside in the "fermentable" character of starchy food, for the flatulence of atonic dyspepsia is not due to fermentation, but there is no doubt about the practical harmfulness of the carbohydrates, explain it how one may.

Restriction of fluids is also of special importance in cases of flatulence, tea, especially, being peculiarly noxious to these patients. On the other hand, it is in atonic dyspepsia that the moderate use of alcoholic beverages at meals, preferably in the form of a little sound wine, often gives the happiest results, for alcohol is a stimulant both to the secretory and motor functions of the debilitated stomach.

The above general principles may be summed up in the following directions :

DIRECTIONS FOR DIET IN ATONIC AND FLATULENT DYSPEPSIA.

1. The following articles should be avoided :
   Green vegetables (except sieved spinach and cauliflower tops) ; turnip and carrots ; peas, beans, and lentils ; fruits (except the *pulp* of baked apples or of stewed prunes) ; sugar and jam ; soups.
2. Potatoes should be taken very sparingly.
3. Crisp toast, rusks or pulled bread should be taken in place of ordinary bread.
4. Orange- or lemon-juice, or other fresh fruit should be taken once or twice a day. If this disagrees 25 milligrammes of ascorbic acid should be given each day.

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[1] Flatulence may be due to the swallowing of air and can be prevented by placing a cork (½ inch) between the teeth for 10 minutes after meals.

5. *As little fluid as possible should be taken at meals.* A little hot water may be sipped between meals if flatulence is troublesome.
6. Tea should be avoided entirely, and coffee or cocoa taken with plenty of milk unless they disagree.

The above rules are applicable in all cases of atonic dyspepsia of moderate degree.

DISEASES OF THE INTESTINES

In the ***acute diarrhœa*** due to food poisoning all food should be withheld until the acute stage is over. Water should be given by mouth, 4 or 6 oz. every one to two hours, to prevent the body becoming dehydrated. Four to five pints of fluid, 2400–3000 c.c., should be given in the 24 hours. Barley water, rice water, lemon- or orange-juice, strained and well diluted, are all of value, and sugar should be added to the feeds so that at least 200 grammes (6½ oz.) are taken in the day. The fast can be broken either with milk and water, or milk thickened with one of the cereal preparations, arrowroot, rice, cornflour, sago, or one of the patent cereal foods like Benger's or Farex. Gravy soup, well strained, or one of the patent meat extracts are often of great value. Raw meat juice was formerly recommended, but should not be used because of the risk of carrying the eggs of parasites. Albumen water is expensive and offers little advantage over plain water.

In ***acute dysentery*** or ***acute ulcerative colitis,*** when the number of stools is very great, the diet should be the same as that for an acute diarrhœa.

In ***chronic diarrhœa, chronic dysentery,*** and ***ulcerative colitis*** all foods like vegetables and fruits, which leave a residue, are forbidden. A suitable diet is shown in the following table.

LOW-RESIDUE DIET

BREAKFAST.

Tea or coffee with milk and sugar to taste.
Puffed rice, cornflakes, or patent barley, with milk and sugar.
Boiled, poached, or scrambled eggs (not fried), or boiled or steamed white fish, or smoked haddock.
White bread and butter.
Honey, golden syrup, black treacle, strained jelly marmalade, or jelly.

MID-MORNING.

Coffee, cocoa, milk, or any other form of milk food. Sugar to taste.
Plain biscuits (not digestive, wholemeal, coco-nut, Vitaweat, or Ryvita).

DINNER.

Boiled or steamed fish (except herrings and other fish containing small bones), or rabbit, chicken, sweetbreads, brains, tripe (no onion), or minced tender lamb.

Gravy or white sauce (not containing parsley or any other vegetables).

Mashed old potatoes. (No other vegetables are allowed.)

Milk pudding, custard, blancmange, junket, plain jelly, or steamed cake mixture pudding (no fruit, jam, etc.).

Chocolate may be eaten after meals, or used as flavouring.

TEA.

Tea with milk and sugar to taste.

White bread and butter.

Honey, golden syrup, black treacle, jelly, cream cheese, or Marmite.

Sponge or plain madeira cake (no fruit, peel, seeds, or nuts) or plain biscuits (not digestive, wholemeal, coco-nut, Vitaweat, or Ryvita).

SUPPER.

Tea, coffee, or cocoa made with milk, or any other form of milk food. Sugar to taste.

White bread or plain biscuits and butter.

Eggs, white fish, smoked haddock, soft cheese, or pudding.

Mashed old boiled potatoes and sieved vegetables.

BEDTIME.

Cocoa, milk, or any other form of milk food. Sugar to taste.

Plain biscuits if desired.

Well strained and sweetened orange, lemon, or grapefruit juice should be taken two or three times a day.

The foods may be arranged according to taste.

Meals should never be eaten in a hurry, and at least ten minutes' rest should be taken after finishing them.

Foods not allowed.

All foods which leave a residue after digestion. These include:

Biscuits, such as digestive, wholemeal, coco-nut, macaroons, Vitaweat, and Ryvita.

Brown bread, wholemeal, and other varieties.

Fish with small bones (eels, herrings, kippers, bloaters, and sardines).

Fried foods.

Fruits, stewed, tinned, or raw, except strained orange, lemon, or grapefruit juice.

Jams, peel marmalade, and dried fruits, such as currants, sultanas, cherries, etc.

Meat, except rabbit, chicken, sweetbreads, brains, tripe (no onion), or minced tender lamb.

Nuts.

Porridge, Shredded Wheat, and all wholemeal cereals.

Salads and parsley.

Vegetables (unless well sieved), except mashed old potatoes.

If the diarrhœa is associated with ***achylia,*** the diet suitable for this condition should be used (p. 640). If the stools are acid in reaction the amount of starch in the diet should be reduced to a minimum ;

when the diarrhœa has ceased the carbohydrate should be cautiously increased. If the stools are alkaline in reaction the smell is often very offensive. Meat should be withheld, but milk, cheese and carbohydrates are usually well tolerated. When the diarrhœa ceases fish and meat should be added gradually. If the stools are very pale the condition is probably due to excess of fat, steatorrhœa. This occurs in cœliac disease and chronic pancreatitis. (For treatment of sprue see p. 647.) The fat should be reduced to a very small amount. Fresh skimmed milk should be obtained from a dairy (permission from the Milk Marketing Board may be necessary) or one of the dried skimmed milk products should be used. The milk may be thickened with cornflour, etc., and flavoured with coffee or tea. Gravy soups or meat extracts are useful together with starchy foods. Fruit, fresh or cooked, is usually well tolerated but it is usually necessary to strain it. White fish, which contains practically no fat, and lean meat may be added later on. If the patient has either cœliac disease or chronic pancreatitis he must keep to this diet for a long time, and as it is deficient in vitamins, 9000–15,000 I.U. of A and 1800–3000 I.U. of D should be given each day to ensure the proper absorption of calcium. Extra vitamin B should be given in the form of yeast or some concentrated preparation (pp. 696–9). These patients sometimes suffer from a macrocytic anæmia, and either an extract of liver or hog's stomach should be given by mouth or a potent liver extract injected intramuscularly.

When the patient improves extra fat may be added cautiously. It is advisable to estimate the total fat lost in the stool over a period of three days so as to be certain that too much fat is not given. If more than 20 grammes of fat are lost in the day the fat intake should be reduced.

LOW-FAT DIET

BREAKFAST.

Tea or coffee with skimmed milk, fresh, condensed, or dried, and sugar if desired.

Porridge, Shredded Wheat, or other breakfast cereal with skimmed milk and sugar.

Bread and jam, marmalade, honey, golden syrup, or black treacle.

Smoked haddock or white fish if desired.

MID-MORNING.

Tea or coffee with skimmed milk, and sugar if desired, or well-sweetened lemonade.

Plain water biscuits (not petit beurre, etc.).

DINNER.

Boiled or steamed white fish or smoked haddock, with skimmed milk or tomato sauce.

Rabbit or tripe stewed in skimmed milk, stewed liver, boiled or steamed chicken, or very lean meat.

Potatoes, boiled, mashed with skimmed milk, or baked in their jackets.

Green or other boiled vegetables.

Skimmed milk pudding, or blancmange or custard powder custard made with skimmed milk, or boiled rice and jam, or jelly, or summer pudding.

Fresh or stewed fruit.

TEA.

Tea with skimmed milk, and sugar if desired.

Bread and jam, marmalade, golden syrup, honey or black treacle ; or sandwiches made with tomato, mashed banana, Marmite or meat extract, instead of butter.

Buns or plain water biscuits if desired.

SUPPER.

As dinner, or as tea.

Meat extract, Marmite, fat free meat or chicken broth, with rice or tapioca ; or Bournvita or Ovaltine made with skimmed milk may be taken if desired.

BEDTIME.

Bournvita or Ovaltine made with skimmed milk, or well-sweetened lemonade.

Water biscuits, or bread and jam.

Boiled sweets may be taken after meals.

Glucose may be added to drinks and stewed fruit to increase the Calorie value of the diet or when a gain in weight is advisable.

Not allowed.

Baked potatoes, Yorkshire pudding, and all foods baked in fat.

Butter, margarine, dripping, suet, lard, cream, oil, mayonnaise, and all dishes containing these.

Cheese.

Chocolate and cocoa in all forms.

Duck, goose.

Eggs (except egg white in the form of a meringue filled with jam).

Fat fish such as salmon, herrings, bloaters, kippers, sardines, etc.

Fat meat, pork, ham, bacon, sausages, brawn.

Fried foods of all kinds including potato chips, fried onions, fritters.

Nuts, and all sweets and biscuits containing these.

Pies and pastry, cakes, cake mixture puddings, ice cream.

Shortbread, petit beurre and other biscuits containing fat. (Page 325).

Suet puddings, dumplings and crust.

Toffee, caramels, and marzipan.

Whole milk, fresh, condensed, or sterilized.

The dietetic treatment of mucous colitis is difficult. The effect of a low-residue diet, p. 643, may be tried or that of the high residue diet used in the treatment of constipation.

The Treatment of Sprue

This disease of the intestinal tract is characterized by the failure to absorb the fat of the diet although it has been properly digested. The stools therefore are very bulky, pale, and frothy. They do not appear to contain bile pigments or salts, but these are actually present in normal amounts, but the colour of the stool is pale because of the abundance of fat. On general principles a low-fat diet is indicated and the following high-protein low-fat diets have been arranged by N. H. Fairley.[1]

High-protein Diet 1

(Calorie value, 1005)

Carbohydrate 73 grammes, Protein 72 grammes, Fat 45 grammes.

8 a.m.	Underdone beef, 3 oz.; juice of half an orange, and glucose, 2 drachms; rusks, ¾ oz.
12 a.m.	Soup, 4 oz. + liver extract (equivalent to ⅝ lb.); underdone beef, 3 oz.; rusks, ¾ oz.; juice of half an orange, and glucose, 1 drachm.
6 p.m.	The same as at 12 a.m.

High-protein Diet 2

(Calorie value, 1756)

Carbohydrate 128·5 grammes, Protein 128 grammes, Fat 77 grammes.

8 a.m.	Underdone beef, 5 oz.; rusks, 1 oz.; calves-foot jelly, 2 oz.; juice of an orange, and glucose, 2 drachms.
12 a.m.	Soup, 4 oz. + liver extract (equivalent to ⅝ lb.); underdone beef, 5 oz.; rusks, 1 oz.; juice of an orange, and glucose, 2 drachms.
4 p.m.	Tea, 10 oz.; milk, 2 oz.
7 p.m.	The same as at 12 a.m., with calves-foot jelly, 2 oz.

High-protein Diet 3

(Calorie value, 2317)

Carbohydrate 185 grammes, Protein 164·5 grammes, Fat 97 grammes.

6 a.m.	Tea, 10 oz.; milk, 2 oz.
8 a.m.	Underdone beef, 6 oz.; rusks, 1½ oz.; calves-foot jelly, 2 oz.; juice of an orange, and glucose, 2 drachms.
10 a.m.	1 baked apple; custard, 1 oz.
12 a.m.	Soup, 4 oz. + liver extract (equivalent to ⅝ lb.); underdone beef, 6 oz.; calves-foot jelly, 2 oz.; rusks, 1½ oz.; juice of an orange, and glucose, 2 drachms.
4 p.m.	Tea, 10 oz.; milk, 2 oz.; baked apple, 1 oz.; custard, 1 oz.
7 p.m.	The same as at 12 a.m.

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[1] P. Manson-Bahr. (1939), *The Dysenteric Disorders*, 389.

HIGH-PROTEIN DIET 4

(Calorie value, 2782)

Carbohydrate 223·5 grammes, Protein 179·5 grammes, Fat 116 grammes.

6 a.m. Tea, 10 oz. ; milk, 2 oz.

8 a.m. Underdone beef, 7 oz. ; rusks, 1½ oz. ; calves-foot jelly, 2 oz. ; juice of an orange, and glucose, 2 drachms.

10 a.m. One baked apple ; custard, 2 oz.

12 noon. Soup, 5 oz. + liver extract (equivalent to ½ lb.) ; underdone beef, 7 oz. ; calves-foot jelly, 2 oz. ; rusks, 3 oz. ; juice of an orange, and glucose, 2 drachms.

4 p.m. Tea, 10 oz. ; milk, 2 oz. ; 1 baked apple ; custard, 3 oz.

7 p.m. The same as at 12 a.m., but only 1½ oz. of rusks allowed.

HIGH-PROTEIN DIET 5

(Calorie value, 3557)

Carbohydrate 375 grammes, Protein 199 grammes, Fat 123 grammes.

6 a.m. Tea, 10 oz. ; milk, 2 oz. ; glucose, 2 drachms ; rusks, 1½ oz. ; butter, 1 drachm ; one scraped ripe apple or one fully ripe Canary banana (yellow ends).

8 a.m. Underdone beef, 7 oz. ; rusks, 3 oz. ; calves-foot jelly, 2 oz. ; juice of an orange, and glucose, ½ oz. ; honey, 2 drachms ; butter, 1 drachm.

10 a.m. 1 baked apple ; custard, 3 oz.

12 a.m. Soup, 5 oz. + liver extract (equivalent to ⅝ lb.) ; underdone beef, 7 oz. ; calves-foot jelly, 2 oz. ; rusks, 1½ oz. ; juice of an orange, and glucose, ½ oz.

4 p.m. Tea, 10 oz. ; milk, 2 oz. ; glucose, 2 drachms ; rusks, 3 oz. ; baked apple, 1 oz. ; custard, 3 oz. (egg, boiled or poached sometimes substituted) ; honey, 2 drachms.

7 p.m. The same as at 12 a.m.

A high protein milk is used in this diet, which has the following composition : SPRULAC. Moisture 3·0%, fat 10·6%, protein 34·0%, lactose 45·0%, mineral matter 7·4%.

LIVER SOUP.—Three-quarters of a pound of fresh liver is taken, finely minced, and immersed in a quart of water to which, when boiling, a small amount of tapioca or sago and some pepper and salt should be added. After simmering for two hours, the fluid is strained off and allowed to cool. The taste is much improved by adding stock made from beef or chicken bones.

If liver is disliked or unobtainable, full doses of liver extracts should be injected into the muscles.

The tongue which is denuded of its papillæ and is very sore is best treated with riboflavine, 5–10 milligrammes, t.d.s. until the papillæ recover. Nicotinamide, 100–200 milligrammes, t.d.s. should be given at the same time and ascorbic acid, 100 milligrammes a day.

Diets for Acute Sprue. Another treatment consists in giving a diet which consists chiefly of milk, and also gives good results.

Diet 1. First Week

(Total Calorie value, about 1000 Calories)

Three pints (60 oz.) of cow's milk or Benger's food, in 5-oz. feeds at two-hour intervals ; toast ; "pulled bread" ; "Heudebert" rusks ; or digestive biscuits with a scrape of butter.

Diet 2. Second Week

(Total Calorie value, about 1900 Calories)

Three pints (60 oz.) of cow's milk or Benger's food as in No. 1 ; rusks ; toast ; sago, 6 oz. ; liver soup, 12 oz., in two feeds of 6 oz. each. One lightly boiled egg ; weak tea ; or sprue tea (i.e. tea infused with milk) 8 oz.

Diet 3. Third Week onwards

(Total Calorie value, about 3900 Calories)

Breakfast.	Porridge, or gruel ; 1 egg ; toast and weak tea.
11 a.m.	10 oz. milk, Sprulac or Benger's food.
Lunch.	Liver soup, 12 oz. ; minced chicken, 6 oz. ; spinach (or cauliflower), 3 oz. ; sago (or semolina), 6 oz. ; baked apple or mashed banana, 6 oz.
Tea.	Toast ; tea ; madeira cake ; sponge cake ; digestive biscuits (McVitie & Price), 3 oz.
Dinner.	Brain or sweetbread, 4 oz. ; calves-foot jelly, 3 oz. ; arrowroot, sago, or tapioca, 8 oz.

Manson-Bahr has found that this departure from the rigid milk dietary which was formerly advocated is of very distinct advantage to the patient, especially from the psychological point of view. As a rule, patients who are treated in such a liberal fashion do not manifest those signs of unreasonableness and mental irritation so typical of sprue patients whose diet was entirely restricted to milk.

Diet No. 1 is adjusted to a low Calorie value, and while the patient is taking it, he must be kept in bed and carefully nursed. Diet No. 2 is of a higher Calorie value ; the patient may be allowed to sit up in bed and leave the room for a bath. During the third and convalescent diet he may be allowed up in the afternoon.

It has been the custom to augment Diet No. 2 by giving raw or underdone meat up to 8 oz. a day, in addition to the liver soup. For this purpose the raw meat is passed through a fine mincer and spread very finely between two thin slices of bread. Diet No 3 is instituted from the third week onwards and is adapted to the special needs of each particular patient; it is usually found necessary to persist with this dietary until the stools have become normal in size and of average consistency and colour.

One would have expected that the results would be better if skim milk with its low fat content were used instead of ordinary milk, as the bulk of the stools would decrease at once.

It has been shown that folic acid (page 162), 10 mg. twice daily by mouth, will cure the macrocytic anæmia of sprue and will also cure the intestinal condition so that the stools become normal in fat content and consistency. Some kinds of non-tropical sprue are also cured but apparently the condition in children known as coeliac disease is not improved though the anæmia is cured.[1–3]

Fresh fruit like strawberries, bael fruit, and papaya had a great reputation for the treatment of sprue. These, like many fruits, are useful, but probably owe their value to their vitamin C content and perhaps other vitamins.

Constipation may be troublesome when the acute stage is over, and boiled onions, spinach, vegetable marrow, and especially cauliflower stalks are of great value.

Diet in Constipation

Constipation [4] is usually due to one of three main causes, two of which may be helped by diet. The first is ***dyschezia*** or failure of the defaecatory reflex due to careless habits, etc., in the past. Diet is of little avail in this state. The body must be re-educated to perform the reflex.

The second cause is ***spasticity of the colon,*** usually more marked in the ascending colon than the transverse or descending colon, though spasticity may extend to them as well. A large

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[1] Lopez, Spies, Toca. (1946), *Journ. Amer. Med. Assoc.*, **132**, 906.

[2] Moore-Bierbaum; Welch and Wright. (1946), *Journ. Lab. & Clin. Med.*, **30**, 1056.

[3] Darby-Jones and Johnson. (1946), *Journ. Amer. Med. Assoc.*, **130** 780.

[4] Readers interested in this common and much advertised complaint are advised to read Alvarez's "Nervous Indigestion," Barclay's "The Alimentary Tract" and Hurst's article in the *Encyclopædia of Medicine*, III, 582. From the *Lancet*, 1939, I, 597, we cull the following on the centenary of the publication of Sir Henry Holland's *Medical Notes and Reflections*. "It is certain," wrote that physician to the Royal Family, "that the natural constitution of different persons is very various as to this point, as well as the constitution of the same person at different periods of life. The cases are common of individuals in perfect health who have action of the bowels only every second or third day." Alvarez is saying the same to-day (*op. cit.*).

percentage of the cases of chronic constipation are due to this cause, the estimates by American physicians ranging, according to Cowgill, from 20 to 50 per cent. Alvarez, at one time, was inclined to put it still higher. In this condition of the gut, the circular muscles are firmly contracted and they reduce the colon to a hard rubber-like tube, easily felt through the abdominal wall, along which material is slow in passage.

As anything irritating to the gut in the way of coarse fibres of vegetables, bran, and seeds of fruit such as tomatoes and figs increase its spasticity such foods are contraindicated and a *low-residue diet* should be given. Attempts to relieve this type of constipation by recourse to the so commonly recommended roughage result in pain in the right lower quadrant of the abdomen as the consequence of distension of the cæcum, and appendicitis may be suspected.

The only difficulty to be met in a low-residue diet is the supply of vitamin C. This should be regularly given in the form of well-strained orange-, lemon-, grapefruit, blackcurrant and rose-hip juices, or tomato-juice. The foods to avoid are brown or wholemeal bread, digestive and coco-nut biscuits or macaroons, dried fruits, wholemeal flour, fruits with edible pips and skins such as gooseberries, currants, figs, etc., green vegetables, coarse root vegetables, jams with pips and skins, nuts, oatmeal, peas and beans, shredded wheat, salad vegetables. The foods to take are plain biscuits, white bread, butter, plain cake with no fruit, cheese, cream, eggs, steamed white fish, golden syrup or black treacle, honey, jelly, juices of grapefruit, lemon, orange, or tomato, meat, milk in moderation, rusks, fairy toast, or pulled bread and sugar.

The third cause is ***lack of tone in the muscles*** of the large intestine, the exact opposite of the state of spasticity described above. It is possible that this type of constipation is due to over-activity of the sympathetic system—see the effect of cutting the sympathetic nerves to the large intestine in Hirschsprung's disease, which is an exaggerated form of atonia of the colon—and that the spastic colon is due to over-activity of the parasympathetic nerves.

Dietetic treatment of *atonic constipation* is along the lines of giving foods which leave a large amount of residue in the intestine.

Generally speaking, all foods rich in cellulose belong to this class, e.g. oatmeal, green vegetables, wholemeal bread, and some fruits. All of these should therefore find a place in the diet. Water also acts in a large measure mechanically by increasing the fluidity of the intestinal secretion, but in part also its action may be reflex. It is best given cold the first thing in the morning. In districts in which the water contains much calcium a pure artificial aerated water may be taken instead (e.g. Salutaris). Fats and oils, too, act as mechanical lubricants, and sufferers from constipation should partake of all of them freely, especially if the motions are small and dry. Honey, treacle, and marmalade have also a slightly aperient action.

It is probable, indeed, that vegetable foods owe their laxative properties in part to the fact that they are apt to undergo fermentation in the intestine, with the production of lactic and butyric acids, hydrogen, methane, carbon dioxide and hydrogen sulphide. These substances chemically and mechanically stimulate the muscles of the gut to activity.[1]

Beverages like beer, stout, and cider often have a laxative action, though they may cause colic in some patients. Red wines are thought to be astringent, but the constipation which ensues may be due to the small amount of fluid which the wine drinker takes in the day.

It was thought at one time that milk and eggs were a cause of constipation. It is difficult to be certain on this point as larger amounts of these foods are usually given when the patient is strictly confined to bed, which of itself often causes constipation. It is probable that some patients are affected either by milk or eggs, but the majority are unaffected. Tea and coffee are said to cause constipation in some patients.

The amount of fluid taken in the day should be at least 3 pints.

These principles are expressed in the following rules for patients :

DIRECTIONS FOR DIET IN CHRONIC ATONIC CONSTIPATION.

1. The following foods should be partaken of freely :
   Porridge made from medium oatmeal ; wholemeal bread ; gingerbread and "ginger snaps" ; green vegetables ; fruits (fresh or stewed—especially stewed prunes or figs and baked apples) ; marmalade, honey and treacle.
   Fats—e.g. bacon fat, butter, salad oil.
2. A glass of cold water should be taken on rising, and a few French plums may be eaten before going to bed.
3. A vegetable mucilage should be prescribed as it increases the bulk of the stools. Agar-agar is suitable and the usual dose prescribed is one teaspoonful once or twice a day. Psyllium seeds are also used, but they are not recommended as they may cause irritation.[2]

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[1] LAWRENCE and MCCANCE. (1929), *Med. Res. Council Special Report Series*, No. 135,

[2] HURST. (1938), *Encyclopædia of Medicine*, 3, 582.

Diseases of the Liver

The new hypothesis for the causation of cirrhosis of the liver has been discussed on pp. 69–70 and at present holds the field. The most important step in treatment is to persuade the patient to refrain from taking alcohol and this in severe cases is best done in a special home. The diet should contain an adequate amount of protein, 70–100 grammes a day, and should contain at least 1 pint of milk—better 2 pints—a day, and at least 2 oz. of cheese. This will ensure that plenty of methionine is absorbed and so help to reduce the fatty infiltration of the liver. The fat in the diet in the form of butter and cream should be reduced to a minimum and the fat of meat and fat fish should be avoided. It was customary to restrict the spices and condiments. This was probably due to the occurrence of cirrhosis of the liver in India where highly spiced foods are eaten by people who do not take alcohol. In the light of the new work on choline and methionine this limitation seems unnecessary. Methionine may be of value in the treatment but its use has not been reported yet.

At the outset the diet can be arranged as for the treatment of a gastritis but eggs are best avoided because of the high cholesterol content, if the patient has obstructive jaundice. The amount of carbohydrate should not be too high, say 250 grammes, but can be increased later on. The diet should then consist of:

80–100 grammes of protein .	320	or	400	Calories.
50– 80 grammes of fat . .	450	or	720	„
250 grammes of carbohydrate	1000		1000	„
	1770		2120	

The protein and carbohydrate content can be increased when the appetite returns.

Jaundice may be due to many causes but the general principles of diet are—so far as is known—the same. The fat of the diet should be as small as possible for two reasons. Firstly, because if the bile is not entering the duodenum the fat will be poorly absorbed in the absence of the bile salts, which lower the surface tension of the intestinal contents and so aid the fat globules to pass through the epithelium. The stools are apt to be very offensive if much fat is present in the large intestine owing to bacterial decomposition. Secondly, it is important for the health of the liver that the fatty content should be as low as possible. The type of low fat, high carbohydrate, high protein diet which is recommended for the treatment of cirrhosis of the liver is suitable. The cholesterol should be small in amount if the jaundice is obstructive since it is excreted in the bile. In the treatment of infective hepatitis it is customary to inject in addition 6–10 units of protamine zinc insulin once a day, partly to ensure that the high carbohydrate diet does not cause any hyperglycæmia and partly to ensure that the liver contains sufficient glycogen. The proteins which have a high content of methionine—milk and cheese—should be taken as well as lean meat, but eggs and fat fish should be avoided.

Wilson, Pollock and Harris,[1] and Higgins, O'Brien, Peters, Stewart and Witts,[2] have tried to shorten the course of the disease—infective hepatitis—by giving methionine 5 grammes a day by mouth, but the course of the disease was quite unaffected.

The 5 grammes of methionine was dissolved in a solution of 1·4 c.c. of concentrated hydrochloric acid and 142 c.c. of water. An ounce of the solution containing 1 gramme was given five times a day. Higgins *et al*, 1945.

Beattie,[3] on the other hand, working with patients who had developed infective hepatitis during treatment with arsaphenamine, thought that he could reduce the time the patient spent in hospital by 37 per cent. by giving a very high protein diet—150 grammes a day. He also gave methionine intravenously and obtained good results provided the total protein of the diet was high.

There are but few indications to be met in the dietetic treatment of cases of ***gall-stones.*** Seeing that the taking of food into the stomach stimulates the expulsion of bile, it will be well to see that the meals are rather frequent—at least five being taken in the course of the day. The amount of cholesterol ingested should be reduced as much as possible by omitting eggs, brains, sweetbreads, liver, kidneys, peas, and beans, since these foods contain more cholesterol than others. It is believed that this procedure reduces the liability to the formation of gall-stones, but of course it cannot affect stones which have already formed. Most clinical observers are agreed that the drinking of large quantities of water is advisable, even although there is no actual experimental evidence to show that the fluidity of the bile is increased thereby.

In cases of "***biliousness***" or "***chill on the liver***"—a condition which is perhaps due to a functional disorder of the liver, the diet should be reduced to gravy soups, meat extracts, dry toast, or biscuits. This diet should be maintained for at least 24 hours, or until the condition has improved. The diet may then be increased by the addition of fruit juice, or cooked fruit, milk, steamed fish, lean meat, potatoes, cheese. If this is well borne the diet should be increased but the fat content should be kept low and all alcohol forbidden for at least three days.

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[1] (1945), *Brit. Med. Journ.*, **1**, 399.

[2] *ibid.* **1**, 401.

[3] Beattie. (1943–44), *Royal College of Surgeons Scientific Report.*

4. *Disorders of the Circulation*

The stomach is only separated from the heart by the diaphragm and any distension of the stomach will tend to embarrass the heart's action. If the latter is impaired it is very important to prevent the distension of the stomach with wind, and the diet which is suitable for a flatulent dyspepsia should be used (p. 642).

When a severe degree of cardiac dropsy is present, a dry diet is usually advised. The ***Karell Diet,*** first introduced in 1865, consisted, in its original form, of 200 c.c. (7 oz.) of skimmed milk given four times a day. The amount of fluid is very small and most patients are unable to tolerate it for more than a day or two. If, however, the amount of fluid is increased to 1000 c.c. (35 oz.) the treatment is believed to be of value. It is better to give the drinks at more frequent intervals, and six feeds of 150 c.c. (5 oz.) should be given during the day, and one during the night. At least two feeds should consist of orange- or lemon-juice to which 15 grammes of sugar is added and the other five of milk, to which 15 grammes of lactose has been added. It is important to flavour the milk with coffee, cocoa, Ovaltine, or Benger's Food, etc., so as to prevent the patient tiring of the milk. Such a diet would contain approximately 170 grammes carbohydrate, 26 grammes protein, and 25 grammes fat, calories 985. As soon as the patient is better, biscuits, toast, cereals, eggs, should be added to the diet. Excess of salt should be avoided, but a salt-free diet should not be given.

The value of ascorbic acid has been stressed by W. Evans.[1] He compared the action of 75 or 150 milligrammes of ascorbic acid with theobromine, ammonium chloride, digitalis, and mersalyl, on eight patients with cardiac failure associated either with normal rhythm or with auricular fibrillation. The ascorbic acid increased the urinary output in every case and was sometimes more efficient and at other times less so than the other remedies. Unfortunately the excretion of ascorbic acid was not estimated in these cases and it is impossible to say whether the patients were in the subscurvy state or not. The experience of one of us (G. G.) suggests that the ascorbic acid will only be of benefit where the previous diet has lacked vitamin C. It is, therefore, important to make certain that a good diet has been taken and if this is not the case extra ascorbic acid should be given.

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[1] Evans, W. (1938), *Lancet*, **1**, 306.

A semi-starvation diet has been recommended in the treatment of ***angina of effort, coronary thrombosis,*** and of ***hypertensive heart disease.***[1] This treatment lowers the basal metabolic rate and so reduces the demands of the coronary circulation. If the patient is overweight it is very important to make him lose weight as this by itself will reduce the work of the heart on exertion. The diets suggested for weight reduction (p. 603) should be used. The overweight patient will not lose protein and therefore muscle in the process. If the patient is already underweight it seems unwise to reduce the caloric value as the patient will probably have to use his own muscles for energy purposes and so weaken them.

The dietetic treatment of ***aneurism*** must be mentioned in order to condemn it. In the past reliance was placed on ***Tuffnell's treatment.*** The fluid intake was reduced to 10 oz. and only dry articles of food were allowed.

5. *Anæmia*

In the treatment of mild chronic secondary anæmia the amount of iron in the diet should be increased. Foods rich in the metal (pp. 117–19) should be partaken of freely.

A great advance in the treatment of pernicious anæmia has been made by the work of Minot and Murphy,[2] Castle, and many others. It was found that the anæmia disappeared when patients were fed on liver. Half a pound was eaten each day either fried or stewed, or raw, suspended in soup and other meat extracts. After the blood had become normal 5 oz. was sufficent to maintain health. Most patients soon got very tired of eating this amount of liver every day, and often abandoned the diet. Further research has resulted in the preparation of extracts of hog's stomach and liver which can be taken by mouth. These are less effective than the concentrated liver extracts which are injected intramuscularly. These are now so potent that a monthly injection will maintain a normal blood picture.

The rest of the diet in pernicious anæmia should consist of starchy foods with plenty of meat, vegetables and fruit. Fats should be kept rather low.

Folic acid. It has been shown that this fraction of the B complex (page 162) when given by mouth, 10 mg. twice daily, will cure the anæmia of pernicious anæmia and other hæmolytic anæmia.[3]

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[1] PAUL WHITE. (1937), *Heart Diseases*, 564, 599, 364, 327.

[2] MINOT, G. R., and MURPHY, W. P. (1926), *Journ. Amer. Med. Assoc.*, 87, 470; CASTLE, W. B. (1929), *Amer. Journ. Med. Sci.*, 177, 748. Cit. VAUGHAN, J. (1934), *The Anæmias*, Oxford Med. Press.

[3] SPIES and STONE. (1947), *Lancet*, 1, 174.

6. *Respiratory Diseases*

Pneumonia. The diet in pneumonia should proceed on the same principles as in any other acute fever; but as the disease is usually one of short duration, and as the digestive functions are apt to be considerably impaired, particular care should be taken not to overload the stomach. From 2 to 3 pints of milk, plain, diluted, or citrated, with half a pint of broth should be sufficient in the 24 hours. Weak tea may be allowed, and plenty of water or barley water. The use of alcohol is unnecessary unless the patient has habitually taken a great deal and is miserable without it.

Bronchitis. In acute bronchitis a diet of "hot slops" (hot milk, broths, gruels, tea, etc.) is best, as it tends to promote secretion from the tubes. In chronic bronchitis the diet should be much on the lines of that in cases of cardiac disease (p. 655), but in ill-nourished patients plenty of digestible fats should be given.

Pulmonary Tuberculosis. The diet in this condition should follow the principles applicable in all cases of tuberculosis (p. 610), but may require modification in accordance with the digestive capacity of the individual patient.

Asthma. In some cases the asthma attack is directly related to some article of food which the patient has eaten, e.g. an egg or wheat proteins. Every effort should be made by careful enquiry and by the use of skin tests to discover whether this is the case. If so, the noxious food should either be forbidden entirely or an attempt should be made to desensitize the patient by means of subcutaneous injections of an alcoholic extract of the food.

7. *Renal Diseases*

In the dietetic treatment of ***nephritis*** there are two general principles which should be observed, (1) to avoid the ingestion of any article of food whose breakdown products may irritate the kidney; (2) to lighten the work of the kidney by reducing the amount of urea, uric acid, creatinine, and salt, which has to be excreted.

Amongst the substances calculated to irritate the kidney in the process of their excretion are such articles as spices, mustard, pepper, curry, ginger, radishes, and perhaps asparagus. Alcohol, especially in concentrated forms, is also strongly contra-indicated as some of it is always excreted in the urine, and of non-alcoholic beverages ginger ale should be avoided, owing to the fact that it contains either ginger or capsicum or both.

The various types of nephritis demand very different dietetic treatment.

(*a*) ***Acute diffus nephritis associated with hæmaturia, little or no œdema, but with retention of urea in the blood.*** Formerly this type of disease was treated with milk, and some physicians gave their patients 3 pints of milk in the day for long periods. This diet contains C. 80, P. 60, F. 60, Cals. 1156, sodium chloride 0·72 grammes (11·1 grains). The amount of nitrogen which has to be excreted in the urine on this diet is 8·4 grammes (allowing 1 gramme for excretion in the stools), provided that the patient is in nitrogenous equilibrium. But as the total Caloric value of the diet is only 1156 (or about 844 less than the 2000 Calories which are assumed to be necessary for a patient lying in bed) the patients will not be in nitrogenous equilibrium. Such a patient will use up body proteins and will excrete more than 8·4 grammes of nitrogen a day. These considerations show that a diet of milk by itself is not a satisfactory one.

Recently, the use of orange- and lemon-juice with the addition of sugar has been recommended as putting the least possible strain on the kidney.

This diet is very palatable when patients are unwell and is of especial value if they suffer from nausea or vomiting. Under these conditions 2 to 3 oz. should be given every hour. The Caloric value of this diet, if 250 grammes of glucose are given, is only 1000, and as the diet does not contain any protein the patient will not be in nitrogenous equilibrium, and will have to break up valuable body proteins. A boy of 12, with acute nephritis, whose blood urea was within normal limits, lost 66·6 grammes of nitrogen in the urine in the course of 12 days daily (an excretion of 5·5 grammes of nitrogen or 11·8 grammes of urea (Fig. 28). If the 1 gramme which was possibly lost in the stools each day is neglected, the total loss of protein in the 12 days was 346·8 grammes, and the total loss of flesh (66·6 grammes nitrogen × 30) 1998 grammes or nearly 4 lb. In the next 7 days he was given 36 grammes of protein and 200 grammes of sugar and 50 grammes of fat, total Calories 1486. He excreted slightly more nitrogen in the urine, 6·81 instead of 5·51 grammes, and the average daily loss of nitrogen was 0·41 grammes (neglecting the possible loss of 1 gramme of nitrogen in the stools ; the total nitrogen lost in 12 days was 4·92 grammes. When an additional 100 grammes of carbohydrate, Calories 1896, was given the average daily excretion of nitrogen in the urine was 5·67 grammes, and a positive balance of 0·63 gramme was attained (neglecting the possible loss of 1 gramme of nitrogen in the stools).[1] This experiment showed that a diet consisting of orange juice and sugar caused a loss of valuable protein while a diet containing 36 grammes of protein with adequate amounts of fat and carbohydrates preserved the body protein, and increased the secretion of nitrogen by the kidney from 5·5 to 5·67 grammes only ; a negligible amount which could certainly have been prevented by giving another 25 grammes of glucose or 100 Calories. If the kidneys are incapable of doing their work, as shown by an increase in the blood urea, it is clearly of importance to keep the protein of the diet as small as possible. Chittenden[1] enjoyed excellent health and was kept in nitrogenous equilibrium for nine months on 36·6–40 grammes of protein. This diet necessitated the excretion of from 4·86 to 5·4 grammes allowing for the daily excretion of 1 gramme of nitrogen in the stools.

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[1] Figures of a case of acute nephritis treated by one of us (G. G.) unpublished.

These considerations show that it is desirable in cases of acute nephritis, in which retention of urea occurs, to reduce the protein to 36–40 grammes. When the blood urea is very high the total protein of the diet may be reduced to 25 or 30 grammes for a short while. When such a small amount of protein is being eaten, nearly all of it should consist of first-class proteins, and the caloric value of the diet must be higher than the 2000 Calories, which is suitable for a patient lying in bed ; say 2500–3000. If the caloric value is not adequate the patients will not be in nitrogenous equilibrium and will have to break up their body proteins. If this occurs the general nutrition of the body will suffer and the kidney condition will deteriorate. When a very low protein diet is given, it is essential to estimate the total amount of nitrogen excreted in the urine in the 24 hours for two to three days, to make certain that the caloric value of the diet is adequate to spare the body proteins. Alving[2] believes that patients do better with a higher protein intake, although the blood urea is too high. He thought this was caused by an improvement in the general nutrition of the patient. It may be due to the fact that it is much easier to keep a patient in nitrogenous equilibrium with a protein intake of 50 60 grammes than with only 30 grammes, since the caloric intake need not be so high.

The kind of protein which should be given has been much disputed. The milk proteins were regarded as of especial value and no other kind of protein was allowed. Later it was realized that egg albumin was as free from objection as milk, and later still also that fish proteins were not injurious and comparatively recently that meat proteins could be given without causing any harm to

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[1] Cit. GRAHAM LUSK. (1919), *Science of Nutrition*, 337.

[2] ALVING, A. S. (1934), *Medical Clinics of N. America*, 17, 1195.

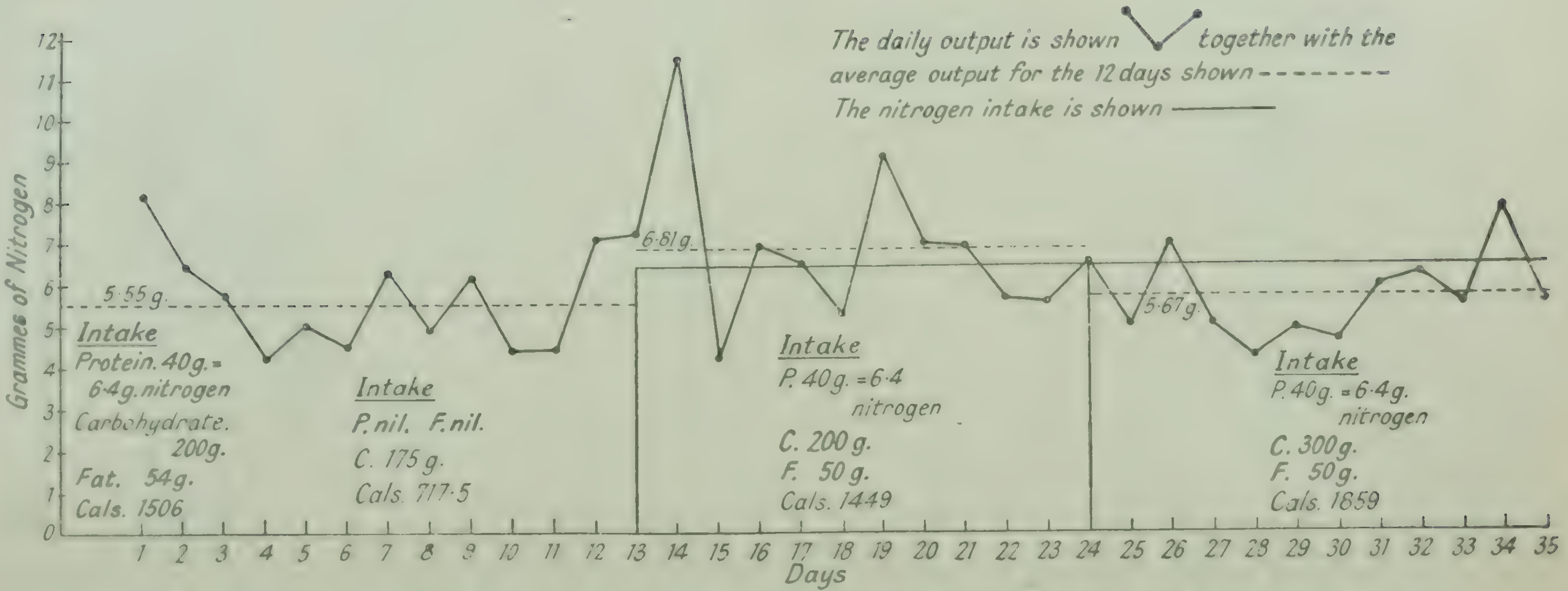

FIG. 28 SHOWS THE OUTPUT OF TOTAL NITROGEN DURING THREE 12-DAY PERIODS BY A BOY AGED 13½ WITH ACUTE NEPHRITIS.

The blood urea was within normal limits throughout the period. The urine contained blood and albumin. The nitrogen in the fæces was not estimated.

the patient. All the four kinds of proteins mentioned are digested in the same way (see p. 241) and are broken down by the pepsin and trypsin to the stage of polypeptides and then absorbed into the bloodstream in the form of amino-acids. They are then either (1) deaminized and the nitrogen is converted into urea in the liver or into ammonia by the kidney, and so excreted into the urine, while the carbohydrate moiety is utilized for energy purposes, or (2) used for building up or repair of the body proteins, such as the albumin, globulin, and fibrinogen of the blood. But fish, besides proteins, also contains purine bodies, and meat contains the extractives creatinine and creatin as well as the purines. Thus the eating of fish and meat increases the intake and therefore the output by the kidney of uric acid and creatinine. They should therefore be avoided when the blood urea is raised above the normal 40 milligrammes per 100 c.c., but if it is normal, fish and meat proteins are not contra-indicated.

These considerations suggest that the diet should be arranged as follows:

(1) At the onset of the disease and especially if the patient is very ill with nausea and vomiting, the diet should consist of orange-juice and water and at least 250 grammes of glucose. Some loss of valuable muscle protein is inevitable at this stage.

(2) As soon as the patient has lost the nausea, a low-protein diet containing 36–40 grammes should be given together with a high-carbohydrate diet, sufficient to prevent the breakdown of body proteins. The protein should be in the form of milk, eggs, bread, rice, etc. The fat should be 50 grammes or less.

(3) If and when the blood urea is normal the total protein of the diet may be increased to 50–60 grammes (an excretion in the urine of 8–9·5 grammes nitrogen), and fish and meat may be added to the diet if the patient desires them, and the carbohydrate and fat increased so as to keep the patient in nitrogenous equilibrium.

(*b*) The treatment of ***chronic diffuse nephritis which is associated with much œdema, and little or no hæmaturia.*** In this condition the blood urea is usually normal but large amounts of protein, 10–15–30 grammes, may be lost each day ; the total blood proteins are reduced from 7 to 4·5 grammes or less owing to the loss of albumin and to a lesser extent of globulin. The osmotic pressure of the albumin is high, and when the amount of albumin is less than 2 grammes œdema appears. A cardinal point of treatment is therefore the raising of the amount of albumin in the blood above the critical level. The best way of doing this would be to stop the loss of albumin by the kidneys, but apart from keeping the patient warm in bed and protected from chill, no remedies are available. Since the albumin of the blood must be built up from the amino-acids derived from the foods, the amount of protein in the diet is important. The amount lost each day may be as high as 15–30 grammes and if the intake were only 36 grammes the destruction of the body proteins would be considerable. It is essential to increase the protein intake but it is difficult to say how much should be given.

Epstein [1] recommended that a high-protein diet should be given, of the following composition—protein 120–140 grammes, carbohydrate 150–300 grammes, fat 20–40 grammes, Caloric value 1293–2176. Alving [2] thought that patients did better with a diet consisting of 90–125 grammes of protein, and a Caloric value of at least 2500. The physiological evidence suggests that the body must be in nitrogenous equilibrium if new albumin is to be made. If this is the case the large amount of amino-acids circulating in the blood should aid in the formation of new albumin. If the concentration of the albumin increases in the blood, it will drain fluid from the tissues into the blood and so disperse the œdema. A high-protein diet also aids in the excretion of water since urea is a good diuretic, and the additional urea, derived from the protein, is of value in this respect. McLean recommended that 30 grammes of urea should be given by mouth for this purpose. It seems a pity not to give the extra protein which will supply the urea for diuretic purposes and at the same time provide the amino-acids which may be used for the formation of albumin.

It must be remembered that a high-protein diet should never be given if the blood urea is over 40 milligrammes per 100 c.c. and that it should be estimated at weekly intervals whenever such a diet is given. A kidney which is capable of excreting 8 grammes of nitrogen a day may fail badly if it is required to excrete 16 to 20 grammes. If the blood urea begins to rise, the protein intake should be reduced at once and the blood urea estimated more frequently.

A salt-poor diet is often of value when œdema is present, for the salt may be retained and with it an isotonic equivalent of water, which will increase the œdema.[3] When this diet (details on pp. 676–8) is given the plasma chlorides should be estimated at intervals, and if the figure falls below 370 milligrammes per 100 c.c., the intake of sodium chloride should be increased. It is unnecessary to restrict the intake of water provided a salt-poor diet is prescribed, for water by itself is readily excreted. An intake of at least 2000 c.c. (3 pints 8 oz.) should be allowed, as an intake of 1000 c.c. (1 pint 9 oz.) makes life unpleasant for the patient.

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[1] Epstein. (1917), *Amer. Journ. Med. Sci., Journ. Amer. Med. Assoc.,* 1917.

[2] Alving, A. S. (1934), *Medical Clinics of N. America,* **17**, 1195.

[3] Alving, A. S. *ibid.*

Chronic Renal Disease. (Chronic Interstitial Nephritis). This condition is often associated with (1) a raised blood pressure, and (2) a raised blood urea. It is doubtful whether the height of the blood pressure can be influenced by any article of food. The custom of spending one day each week in bed and abstaining from meat or soup on that day probably owes its beneficial effects to the rest and not to the avoidance of meat and its extractives. Alcohol should be forbidden when the blood pressure is high. If the patient is overweight he should submit to the dietetic régime suitable for obese patients (p. 603). If the blood urea is raised, a low-protein diet of high caloric value should be given sufficient to keep the body in nitrogenous equilibrium.

The condition is usually associated with an acidæmia, and the alkali reserve may be considerably less than the normal values of 55 to 70 volumes (25–35 milli-equivalents) of carbon dioxide for 100 c.c. blood. It may be associated with an alkalæmia if much vomiting has occurred, with the result that the alkali reserve may be 80–90 vols. (36–40 milli-equivalents) per 100 c.c. blood. If the alkali reserve is only slightly lowered, say to 50 vols., it may be raised to within normal limits by avoiding the acid-forming foods like meat and eating those forming alkalies like vegetables (p. 129). If this is unsuccessful and if the alkali reserve is less than 50 volumes of carbon dioxide per 100 c.c. blood (25 milli-equivalents), a definite dose of alkali, say 2–6 grammes (30–90 grs.) of sodium bicarbonate, must be taken two or three times a day; the alkali reserve must be estimated at intervals to make certain that the correct dose of alkali is given. If the alkali reserve is slightly too high, say 75 vols (33·7 milli equivalents) per 100 c.c., more acid and less alkali forming foods should be eaten. If this fails or if the alkali reserve is over 75 vols. (33·7 milli-equivalents) per 100 c.c., acid sodium phosphate, 1–3 grammes (15–45 grains), should be given by mouth.

The plasma chloride varies between the normal limits of 580–620 milligrammes (96–106 milli-equivalents) per 100 c.c. and in cases of renal failure it often varies inversely with the alkali reserve. When the latter is high, the plasma chloride is low and cannot be raised by increasing the salt intake of the diet. This is the experience of one of us (G. G.). An intravenous injection of 1000–2000 c.c. of normal physiological saline or Ringer's solution containing 9–18 grammes of sodium chloride will raise the plasma chlorides and depress the alkali reserve temporarily; further treatment must

DIET FOR ACUTE NEPHRITIS

	Carbo-hydrate.	Protein.	Fat.	Calories.
1st Feed :				
4 oz. Milk	5·0	3·6	4·4	76
1 oz. Bread (Butter from ration)	15·0	2·4	0·3	70
2nd Feed :				
4 oz. Orange-juice	10·0	—	—	41
1 oz. Sugar	28·4	—	—	116
3rd Feed :				
4 oz. Milk	5·0	3·6	4·4	76
1 oz. Bread (Butter from ration)	15·0	2·4	0·3	70
½ oz. Jam	10·0	—	—	41
4th Feed :				
4 oz. Orange-juice	10·0	—	—	41
1 oz. Sugar	28·4	—	—	116
5th Feed :				
4 oz. Milk	5·0	3·6	4·4	76
1 Egg	—	6·8	7·0	92
1 oz. Bread (Butter from ration)	15·0	2·4	0·3	70
6th Feed :				
4 oz. Orange-juice	10·0	—	—	41
1 oz. Sugar	28·4	—	—	116
7th Feed :				
4 oz. Milk	5·0	3·6	4·4	76
1 oz. Bread (Butter from ration)	15·0	2·4	0·3	70
¾ oz. Jam	15·0	—	—	61
8th Feed :				
4 oz. Orange-juice	10·0	—	—	41
1 oz. Sugar	28·4	—	—	116
DURING THE NIGHT				
1st Feed :				
4 oz. Milk	5·0	3·6	4·4	76
1 oz. Bread (Butter from ration)	15·0	2·4	0·3	70
2nd Feed :				
4 oz. Orange-juice	10·0	—	—	41
½ oz. Sugar	14·2	—	—	58
Butter ration for the day = 1 oz.	—	—	24·0	220
	292·8	36·8	54·5	1871

This diet contains approximately sixty 5-gramme carbohydrate portions and five 7-gramme protein—5-gramme fat portions, with the addition of 1 oz. of butter. (See "Food Tables," pp. 593–5.)

Diet for Chronic Nephritis with a Raised Blood Urea

	Carbohydrate.	Protein.	Fat.	Calories.
Breakfast.				
½ oz. Dry Oatmeal as porridge	10·3	1·9	1·1	60
4 oz. Milk for tea and porridge	5·0	3·6	4·4	76
2 oz. Bread	30·0	4·8	0·6	140
1 oz. Jam or Marmalade	20·0	—	—	82
Two 5-gramme portions of Fruit, say 4 oz. Apple	10·0	—	—	41
Midday Meal.				
2 oz. Chicken	—	9	2·2	58
4 oz. Potatoes	20·0	—	—	82
Green Vegetables		Negligible		
Two 5-gramme portions of Fruit, say 4 oz. Orange	10·0	—	—	41
2 oz. Bread	30·0	4·8	0·6	140
Tea.				
2 oz. Bread	30·0	4·8	0·6	140
1 oz. Jam	20·0	—	—	82
1 oz. Plain Cake	15·0	1·8	6·8	130
2 oz. Milk	2·5	1·8	2·2	38
Evening Meal				
1 oz. White Fish	—	5·22	—	33
4 oz. Potatoes	20·0	—	—	82
2 oz. Bread	30·0	4·8	0·6	140
2 oz. Milk	2·5	1·8	2·2	38
Two 5-gramme portions of Fruit, say 2 oz. Banana	10·0	—	—	41
2¼ oz. Butter in the day	—	—	54·0	495
1½ oz. Sugar in the day	42·6	—	—	174
	307·9	43·1	75·3	2970

This diet contains approximately sixty-two 5-gramme carbohydrate portions, and seven 7-gramme protein—5-gramme fat portions, with the equivalent of 2¼ oz. of butter. The diet contains little first-class protein but it can be increased without adding to the total protein if the chicken or fish is increased and potatoes and fruit substituted for some of the bread which contains a good deal of vegetable protein. Thus if the amount of bread in the above diet is reduced from 8 oz. to 4 oz. the protein is reduced from 19·2 to 9·6 grammes which would allow another 2 oz. of chicken. The reduction in the carbohydrate intake of 60 grammes is made up by giving another 6 oz. of potatoes or 2 oz. dry rice as a pudding and six 5-gramme portions of fruit, say, the juice of 3 oranges. (See pp. 593–5.)

be guided by the results of blood analysis. The amount of fluid given to these patients should be considerably increased above the usual amount of two pints a day. A careful watch must be kept for œdema of the back and legs. The kidney is often only able to secrete a urine of low specific gravity and the more fluid it has to secrete the greater the chance that it will be able to excrete the urea and other substances which tend to be retained. The daily intake should be increased to three or four pints in the day. This extra fluid will not be retained in the circulating blood but will be rapidly excreted in the urine, so long as the myocardium is healthy.[1] If the latter begins to fail as shown by the appearance of œdema of the legs the cardiac condition should be treated with the appropriate measures and the fluid intake should not be reduced except as a last resort, as it is very important to maintain the action of the kidneys.

The use of alcohol is contra-indicated in all types of nephritis.

If a high-protein diet is required for the treatment of ***nephrosis*** the protein ration should be increased to 85 or 110 grammes and the fat to 94 or 114 grammes (twelve or sixteen protein-fat portions) (see "Food Tables," pp. 593–5), and the carbohydrate should be increased by 50 grammes (ten 5-gramme portions) so as to maintain the patient in nitrogenous equilibrium.

8. *Diseases of the Nervous System*

Dietetic means are of comparatively little value in the treatment of nervous diseases. In most cases the food must be adapted to the condition of the patient's other organs.

Epilepsy. This condition has in the past been treated with various dietetic restrictions such as abstinence from meat, purines, and alcohol; the substitution of sodium bromide for sodium chloride was also advocated. Experience has shown that none of these régimes has any real effect, but that a ketogenic diet in which the carbohydrate ration is very small in amount and the fat ration very large is of more value.[2] The exact mode of action of the diet in producing this result is obscure; some writers attribute the benefit to an anæsthetic action of the ketone bodies, others to an effect of the diet in diminishing fluid retention in the tissues.[3] McQuarrie[4] found that the patients with no definite lesions and

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[1] PRIESTLEY, J. G. (1931), *Journ. Physiol.*, **55**, 305.

[2] PETERMAN. (1924), *Amer. Journ. Dis. Children*, **27**, 28. (1927), *Journ. Amer. Med. Assoc.*, **88**, 1868.

[3] MORIARTY. (1927), *Amer. Journ. Dis. Children*, **33**, 218.

[4] MCQUARRIE, I. (1933), *ibid.*, **29**, 208.

KETOGENIC DIET

Child aged 3.[1]	Child aged 5.[2]	Child aged 8–12.[3]	Adult.[4]
BREAKFAST.			
Egg ½ oz. Butter	Egg 2 oz. Bacon ½ oz. Butter	Egg 2 oz. Bacon 1 oz. Butter	2 oz. Tomato 4 oz. Bacon ½ oz. Butter 1 oz. Devonshire Cream Coffee
LUNCH.			
One 5-gramme portion of Fruit 1 oz. Devonshire Cream	One 5-gramme portion of Fruit 1 oz. Devonshire Cream	One 5-gramme portion of Fruit 1 oz. Devonshire Cream	1 oz. Devonshire Cream
DINNER.			
1 oz. Fat Meat Green Vegetables ¼ oz. Butter 5-gramme portion Fruit 1 oz. Devonshire Cream	2 oz. Fat Meat Green Vegetables ½ oz. Butter 5-gramme portion Fruit 1 oz. Devonshire Cream	2 oz. Fat Meat Green Vegetables 1 oz. Butter 5-gramme portion Fruit 1 oz. Devonshire Cream	2 oz. Fat Meat Green Vegetables ½ oz. Butter 5-gramme portion Fruit 1 oz. Devonshire Cream
TEA.			
Egg ½ oz. Butter	Egg ½ oz. Butter	Egg 1 oz. Butter	2 Egg Yolks ¾ oz. Butter Green Salad and 1 oz. Olive oil 1 oz. Devonshire Cream
SUPPER.			
1½ oz. Fish ½ oz. Butter	1 oz. Cheese ½ oz. Butter 2 oz. Milk in the day	1 oz. Cheese 1 oz. Butter 2 oz. Milk in the day	1 oz. Ham or Cheese ½ oz. Butter 1 oz. Devonshire Cream 2 oz. Tomato Green Salad if desired
C. P. F. 10 26 98 Cals. 1026	C. P. F. 13 44 149 Cals. 1570	C. P. F. 13 44 199 Cals. 2019	C. P. F. 13·7 49 251·5 Cals. 2500

Note. Bran biscuits or food-valueless biscuits obtainable from Callard & Co. may be taken as desired.

[1, 2, 3] GARROD, BATTEN, and THURSFIELD. (1934), *Diseases of Children.* Third edition, 1582.

[4] ABRAHAM and WIDDOWSON. (1937), *Modern Dietary Treatment,* 225.

those treated before the onset of severe attacks did the best. Thus out of 160 cases treated for several years 36 per cent. were apparently cured, 20 per cent. improved and 43 per cent. not benefited.

The patient is kept in bed for a week and given only water, gravy soup, bran biscuits, and a little orange-juice. The fast is broken with a diet which is calculated in the following way: The caloric requirements of a child at rest should be worked out with the use of the nomograph (p. 48) or from Holt's table (p. 50). The carbohydrate should not be more than 10–13 grammes. The protein is arbitrarily fixed at 1 gramme per kilogramme as the diet will not be of long duration and the remainder of the calories are made up with fat. The diets on p. 667 are suitable.

The diet is given until the fits cease in favourable cases; it is important to continue the diet for another three months when all being well, the amount of carbohydrate can be cautiously increased and the fat gradually decreased.

When the diet is used in the treatment of urinary infections it should be calculated in the same way. For the treatment of an adult a diet containing 10–13 grammes of carbohydrate, 50–60 grammes of protein and 250 grammes of fat should be arranged. The active principle in this case is the excretion of β-oxybutyric acid (Fuller).[1] This kills the bacteria more effectively when the pH of the urine is 5·2 or more. It is usually necessary to give ammonium chloride 1 gramme (gr. 15) in a cachet three or four times a day in order to make the urine sufficiently acid. The treatment is often successful but may fail because the amount of β-oxybutyric acid formed is insufficient. This is often due to the patient breaking the diet and eating carbohydrate.

The diet is nowadays little used as it has been replaced by the administration of (1) mandelic acid, which Rosenheim[2] showed killed the bacteria as well or better than β-oxybutyric acid when the pH of the urine was 5·2, and (2) by the sulphonamide group of drugs, which have the additional advantage that they work best in alkaline urine.

Certain neurological conditions which may either be a severe neuritis or a sub-acute combined degeneration of the cord may occur when the patient has a pernicious anæmia or a hæmolytic anæmia, though it may occur in patients who are not anæmic. The condition is greatly improved by intramuscular injections of a potent liver extract. Folic acid, one of the fractions of the vitamin B complex (page 162) which cures the anæmia, has no effect on the neurological conditions which may develop while the folic acid is being given.[1]

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[1] Fuller, A. T., and Colebrook, L. (1933), *Lancet*, 2, 735.

[2] Rosenheim, M. L. (1935), *ibid.*, 1, 1032.

Chorea is a complication of Rheumatic Fever which usually occurs in children. Special care must be taken in feeding children when the movements are very violent. A fluid diet of this type used for the treatment of an acute fever should be given though the caloric value need not be so high since the temperature is usually normal.

In the treatment of ***headaches***—especially of the periodic migrainous or bilious variety—diet is sometimes of great help. During the attack the patients usually eat and drink very little and should be allowed to have anything they may fancy. The evidence that migraine is caused by certain foods is not convincing, as the offending food is very difficult to determine either by the history or skin tests. If any food is known to be followed by headache it should not be eaten.

Various types of diet are sometimes useful; a strict purine-free diet (p. 614) with the avoidance of the methyl purines in tea, coffee; a considerable reduction in the amount of meat eaten; a strict vegetarian diet; the avoidance of all "fancy" diets. A full caloric diet should be given between the attacks so as to ensure good health.

9. *Diseases of the Skin*

There are four ways in which diet may conceivably influence the skin:[2] (1) By affecting general nutrition; (2) reflexly from the alimentary canal; (3) by giving rise to the absorption into the blood of irritating or decomposition products or by producing allergy; (4) by the elimination through the skin of certain constituents of the food.

It must be admitted, however, that when we come to use dietetic methods in the actual treatment of cutaneous disorders, we find ourselves greatly hampered both by our ignorance of the precise part played by diet in any given case, and by the always unknown factor of personal idiosyncrasy. So much is this the case that it may be said without fear of contradiction that there are but few diseases of the skin in which treatment by diet is of much value, and that the potentialities of this line of attack are much less promising than patients generally believe.

In the great majority of cases of skin disease, therefore, either no special rules of diet are required, or they must be drawn up with reference to the patient's general condition without regard to the state of the skin. There are a few cutaneous diseases, however, in which diet may be of some direct help, and these may be briefly considered.

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[1] SPIES and STONE. (1947), *Lancet*, **1**, 174.

[2] WALTER SMITH. (1898), *Brit. Journ. of Dermat.*, **7**, 328.

Urticaria. This is the clearest instance of a skin disease being affected by diet. The urticarial wheal develops some hours after eating either a common article of food like shellfish, fish, eggs, pork or bacon, milk, cheese, pickles, strawberries, and other fruits, or to some uncommon food to which the patient is sensitive. Sometimes it only develops when the food is not quite fresh. The treatment consists in avoiding the special article of food. This is easy if the food is an uncommon one, but difficult to achieve in the case of a common article like an egg. In the latter case an attempt should be made to desensitize the patient by subcutaneous injections of an alcoholic precipitate of the offending substance.

Eczema. Some cases are caused, or made worse, by some articles of food like rhubarb, tomatoes, sour fruits, pungent articles like ginger, over-ripe cheese, and high game. Children may be sensitive to milk or eggs. Alcohol usually aggravates the condition either because of the impurities which give the flavour to the wine or spirit, or by dilating the skin capillaries. In some cases a strict milk diet may be helpful if it is known that the patient is not sensitive to it. The diet should always be plain and simple, so that any injurious article of food can be easily detected. A low-salt diet does not appear to be of any value. If a patient is fond of rich food and is inclined to be stout, a general reduction of food and drink is often beneficial.

Acne Vulgaris and Seborrhœa. These conditions are apparently made worse by excess of carbohydrate food, and especially of chocolates. It has been found that the constituent in chocolate which aggravates the acne is cocoa butter.

Lupus vulgaris. This condition has been treated with Finsen light for many years and it has long been thought that the improvement which occurs is due to the calciferol which is formed by the ultra-violet rays in skin. Treatment with big doses, 150,000 I.U. of calciferol by mouth, will often cure the condition.

In ***psoriasis*** various " systems " of diet occasionally meet with success. Bulkley[1] recommends absolute vegetarianism, forbidding even milk and eggs, and says he has seen the worst eruptions disappear under such a plan, whilst *per contra* the quite opposite regimen of meat and hot water only,[2] or an exclusively milk diet, has proved successful in the hands of others. In the majority of cases, diet has probably little or no influence.

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[1] *Journn. Amer. Med. Assoc.*, (1908), Feb. 22.

[2] PARKES. (1874), *Lancet*, 1, 722; and MALCOLM MORRIS. (1906), *Practitioner*, 76, 575.

In ***rosacea*** the diet should be arranged to meet any form of dyspepsia which may be present (pp. 623 *et seq.*), but alcohol, tea, coffee, spices, and anything which causes flushing of the face must be rigidly excluded.

In ***pruritus,*** especially of the anus or vulva, all highly-seasoned salted, or preserved foods should be avoided, besides alcohol and coffee. Should diabetes be present, the dietetic indications are, of course, the same as for that disease (pp. 583 *et seq.*).

In concluding this section, one cannot do better than quote the wise words of an eminent dermatologist:[1] "After all, it is in comparatively few cases of skin disease that the diet is really of any particular importance. . . . Put not your faith in printed dietaries, or indeed in any general formularies. Above all, remember that the patient has larger and better opportunities of observation than the doctor, and, if he is a person of ordinary intelligence and self-control, he should be trusted. The doctor, who attempts to dictate as an oracle in the matter of diet, is like Lord Foppington's bootmaker, who insisted that he knew better than his client whether or not the shoe pinched."

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[1] MALCOLM MORRIS, *op. cit.*, 76, 584.

CHAPTER XXIII

SOME DIETETIC "CURES" AND "SYSTEMS"

In the earlier part of this book reference has been made to the so-called milk, whey, koumiss, grape and orange "cures." In the present chapter we propose to deal briefly with some of the more elaborate "systems" of diet which are sometimes useful in the treatment of disease. That such systems are occasionally of great therapeutic value no one can deny, but they must be used discreetly, bearing in mind the dangers and fallacies inherent in all attempts to treat disease on a "system," regardless of the peculiarities of the individual case, and remembering that no such system can ever be a panacea, but is at best of restricted, and often only of temporary, value. The reckless and uncritical advocacy of the faddist can only serve to bring such systems into disrepute.

Vegetarian and Lacto-vegetarian Diet

In a previous chapter (pp. 447–50) the question of vegetarianism was discussed in detail, and the conclusion arrived at that it is not a form of diet which is to be unreservedly commended for healthy persons. None the less, as a mode of treatment in certain cases of disease, such a regimen is deserving of the careful consideration of the medical profession, and all the more that hitherto it has been mainly exploited by the large body of "amateur" practitioners.

There are certain well-recognized peculiarities and properties of a non-flesh diet which justify the expectation that it will prove of use in some morbid states. In the first place, such a diet is comparatively free from the purine-bodies, the share of which in the production of gout has already been discussed (pp. 612–13), besides containing almost always less total protein than a mixed diet. In the second place, a diet from which flesh is excluded, and which contains a large proportion of milk, tends greatly to restrain the process of putrefaction in the intestine. Now, there is some reason to believe that certain obscure conditions of general ill-health may be produced and maintained by the absorption of such putrefactive products. In the third place, such a diet is peculiarly rich in inorganic material if milk, eggs, and cheese are included, and although the part played by these in metabolism is at present but ill-understood, there is yet reason to believe that, by altering the "balance" of the salts in the body, nutrition may sometimes be influenced for good. It also reduces the intake of acid-forming substances and tends to raise the alkali reserve. In the last place, a diet which is of mainly vegetable composition leaves a large residue in the bowel, and may counteract a tendency to constipation of the atonic type with all its attendant evils; moreover it increases the intake of vitamin C.

Much careful observation and clinical experiment will certainly be required before we are able clearly to discern exactly in what cases a diet of this sort is likely to be of benefit, but meantime, the following list of diseases in which there is at least presumptive evidence that a vegetarian or lacto-vegetarian regimen exercises a beneficial influence may be tentatively put forward.[1]

(1) Corpulence complicated by atonic constipation in middle life.
(2) Certain cases of alcoholism.
(3) Some forms of functional dyspepsia and intestinal affections of nervous origin.
(4) Idiopathic neuralgias and those having a gouty basis.
(5) Headaches and other disorders dependent on atonic constipation in neurasthenic, hysterical, and epileptic patients.
(6) Many cases of nervous insomnia.

It is almost always wise to make the change from an ordinary diet gradually, and in many cases it is inadvisable to continue the vegetarian plan for longer than six weeks at a time unless the patient has been greatly benefited.

FRUIT AND RAW VEGETABLE CURES

We have referred elsewhere (p. 438) to the so-called "Grape Cure," but from time to time diets have been introduced into which raw fruit and vegetables enter largely if not exclusively. Lahmann advocated such a diet many years ago, and it has been re-introduced in Germany.[2] Its chief feature is the large use of fresh fruit and raw vegetables with little meat and no common salt, the place of which is taken by a vegetable salt. Fresh milk, eggs, and wholemeal bread are allowed in moderation. Lahmann also advised the use of vegetable fats in cooking.

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[1] See L. KUTTNER. (1902), *Berliner Klinik*, Jan.; ALBU. (1902), *Die Vegetarische Diät* (Leipzig: Georg Thieme), 130.

[2] E. MÜLLER. (1930), *Med. Klinik*, No. 5. See also VON NOORDEN. (1928), "Über Obstkuren und über Rohkost," *Therap. d. Gegenw.*, **69**, 289. It is sometimes called the Sauerbruch-Hermannsdorfer-Gerson Diet after its chief advocates at present (see CHALMERS WATSON. (1930), *The Med. Press*, September 10, 207).

Such a diet is, of course, of low protein and caloric value and from the character of its mineral constituents is "alkalizing." It is to a large extent also "salt free" (see p. 675), and has a laxative tendency.

These diets may be expected to be of use in obesity and atonic constipation and to have some diuretic action, and may be advised in the same diseases and disorders as a vegetarian or lacto-vegetarian regimen.

A diet consisting of the juice of eight to twelve oranges is sometimes recommended. This contains 40–60 grammes of sugar and an excess of vitamin C, but no protein.

THE HAY DIET

In this system it is recommended that protein and carbohydrate should not be eaten at the same meal. It is claimed that an almost unbelievable gain in health results from this procedure. The diet has also been used as a cure for obesity. It has already been pointed out (p. 95) that when protein is eaten without any carbohydrate, the amino-acids are broken down immediately so that the carbohydrate fraction of the amino-acid can be used for energy purposes. The NH_2 group is converted into urea and excreted in the urine. Thus none of the amino-acids are available for conversion into protein for use in the body. The same observation has now been made with the intravenous injections of protein digests for patients who cannot take any food by mouth (p. 688). It was found necessary to give glucose at the same time in order to prevent the excretion of the whole of the nitrogen into the urine within a short time. In the light of this experimental evidence, the principle of eating all the animal protein at one meal without any carbohydrate foods would mean that, all the amino-acids derived from the first-class protein would be lost and that the amino-acids derived from the second-class proteins present in wheat, etc., would have to be used for building up into the body proteins. Thus the experimenters would be much worse off than the vegetarians who do at least use the first-class protein present in milk, cheese and eggs. For these reasons we do not propose to give any details of the diets used as we unhesitatingly consider that they are dangerous.

EXCLUSIVE PROTEIN DIET

That man can live on a predominatingly protein diet is undoubtedly true. The Eskimos have used this diet for ages and

Stefánsson[1] in his Arctic expeditions showed that it was possible to live on animal and fish foods alone. He felt well and was able to undergo great hardships. The amount of fat eaten with the protein is considerable.

He and Anderson lived on this diet for a year in the United States and under close supervision in the Bellevue Hospital for three months, and were passed fit in every respect.

Such a diet was practised years ago under the name of the ***Salisbury cure*** and great claims were made for it; e.g. that it cured or alleviated chronic articular gout, some skin diseases such as psoriasis and certain intractable forms of dyspepsia, especially when associated with atonic dilatation of the stomach. The system has fallen into desuetude and is omitted in this book. The details of the treatment will be found in earlier editions.

ZOMOTHERAPY

By the term "zomotherapy" (*Ζωμος* meat-juice) is meant treatment by raw meat or raw meat-juice. This was used in the treatment of patients with anæmia, neurasthenia, debility, convalescence, and latent, incipient, or active tuberculosis. There is no evidence that raw meat-juice aids these conditions and its use is fraught with some risk since the eggs of parasites may be ingested. Details of the diet will be found in the 7th edition.

LOW-SALT DIET

The average amount of common salt in an ordinary diet is about 10 grammes per day, and although it is impossible, even were it desirable, to construct a genuinely "salt-free" diet, yet by a judicious selection of foods it is easy to reduce the daily intake to about 2 grammes. Such a limitation of salt is of use in the treatment of dropsy, particularly the dropsy of chronic parenchymatous nephritis. It was shown by Widal—to whom much of the credit of introducing the salt-free diet is due—that a chronically inflamed kidney is incapable of excreting common salt freely. It is now known that the sodium is excreted with difficulty while the chlorine ion is readily excreted with potassium. (Blum.) The salt is therefore retained in the body, and, in order that the normal composition of the body fluids may be maintained, water is kept back also, with the result that dropsy sets in. When the amount of salt in the food is reduced the percentage of it in the blood gradually falls, the salt which has been stored up in the dropsical effusion is drawn upon to

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[1] STEFÁNSSON, V. (1936), *Adventures in Diet.*

FOOD LIST FOR LOW-SALT DIETS

Foods Allowed in Strictly Low-Salt Diets.

- Barley sugar
- Boiled sweets
- Bread, low-salt, with or without casein
- Butter, low-salt
- Cornflour
- Cream
- Cream cheese, low-salt
- Flour
- Fruit, fresh, stewed, or tinned
- Fondant
- Gelatine
- Golden syrup
- Green salads
- Honey
- Jam
- Jelly
- Macaroni
- Marmalade
- Meat dishes, low-salt
- Milk, low-salt
- Mustard
- Nuts (not salted)
- Olive oil
- Pepper
- Rice
- Sugar
- Tapioca
- Tomatoes
- Vegetables, raw or boiled without salt or soda (not beetroot, carrots, celery, radish, spinach, watercress)
- Vegetables fried in salt-free butter or olive oil
- Vinegar (distilled white wine)

Additional Foods Allowed in Less Strict Diets.

- Chicken, boiled
- Chocolate
- Fresh fish, steamed or boiled without salt
- Eggs
- Meat, stewed without salt. No gravy
- Milk, cow's
- Vegetables, raw or boiled without salt or soda (beetroot, carrots, celery, radish, spinach, watercress)

Foods Forbidden in Diets with Salt Restriction.

- Bacon
- Baked beans
- Beef, corned
- Beef, salt
- Bloater
- Bread, baker's
- Butter, salted
- Gravy
- Haddock, smoked
- Ham
- Kippers
- Meat extracts
- Olives, bottled
- Salmon, tinned
- Sardines
- Sausages
- Shellfish

make good the deficiency in the blood, and with its withdrawal the dropsy subsides. Such, put briefly, is the rationale of the plan, and of its usefulness in cases of chronic parenchymatous nephritis, and also, though less conspicuously, in cardiac dropsy, and in the ascites of cirrhosis there can be no doubt. A salt-free diet is easily arranged, and the following diets containing 0·1 gramme and 0·5 gramme of sodium chloride are useful.[1]

Low-Salt Diets

Diet I

(*Strict, containing about* 0·1 *gramme sodium chloride*)

Breakfast.

Grapefruit or other fruit, fresh or stewed, with sugar if desired.
Low-salt casein bread, toasted if desired.
Low-salt butter.
Jam or marmalade.
Tea or coffee with low-salt milk and sugar as desired.

Dinner.

Low-salt meat or savoury dish.
Vegetables, boiled without added salt or soda. Low-salt butter may be added as desired.
Stewed fruit.
Cream or custard-powder custard or blancmange made with low-salt milk.
Low-salt casein bread.

Tea.

Low-salt casein bread.
Low-salt butter.
Jam, marmalade, honey, tomato, or mustard and cress.
Tea with low-salt milk and sugar as desired.

Supper.

Low-salt casein bread.
Low-salt butter.
Low-salt cream cheese.
Raw tomato with pepper.
Tea or coffee with low-salt milk and sugar as desired.

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[1] Abrahams, M., and Widdowson, E. M. (1937), *Modern Dietary Treatment.* Baillière, Tindall & Cox, 217, 219.

DIET II

(Less strict, containing about 0·5 gramme sodium chloride)

BREAKFAST.

Grapefruit with sugar.
Low-salt bread.
Low-salt butter.
Boiled egg.
Jam or marmalade.
Tea or coffee with cow's milk and sugar as desired.

LUNCH.

Beef stewed without salt. Curry powder may be added if desired.
Potatoes and boiled rice.
Vegetables boiled without added salt or soda.
Baked apple.
Cream if desired.

TEA.

Low-salt bread.
Low-salt butter.
Jam, marmalade, honey, tomato, or mustard and cress.
Shortbread.
Tea with cow's milk and sugar as desired.

DINNER.

Cold boiled chicken or steamed fish.
Green salad or celery, radishes, or tomato with pepper.
Low-salt bread.
Low-salt butter.
Tea, coffee, or cocoa with cow's milk and sugar as desired.

The salt contents of some common articles of food are—

	mg. per oz.
Ham	595
Bacon	314
Cheese	260
Bread (baker's)	146
Fresh butter	63
Sea fish	34–54
Egg	47
Meat	20
Milk	12
Oatmeal	10
Lentils	10
Flour	8
Nuts	1–8
Greens	2
Rice	2
Potatoes	1
Fruit	1
Freshwater fish	Low
Peas	Trace

THE POTASSIUM-POOR DIET

The preparation of a potent extract from the cortex of the adrenal gland which is now used in the treatment of patients with Addison's disease has greatly increased our knowledge of this disease. It is now known that the adrenal cortex controls the sodium of the body and that in Addison's disease the blood sodium is lower than the normal of 325 to 350 milligrammes per 100 c.c., while the potassium in the blood is increased above the normal of 18 milligrammes per 100 c.c. because the blood volume is concentrated.[1] Further work has shown that there is a direct antagonism between the potassium and sodium of the blood.[2] Thus in a case of Addison's disease an increase in the potassium intake from 1 to 4 grammes lowered the blood sodium from 325 to 310 milligrammes per 100 c.c. in five days and increased the output of sodium in the urine from 220 milligrammes to 440 milligrammes a day.

These observations suggested that a diet containing little potassium might be of value in the treatment of Addison's disease. It has been found that with this diet the expensive cortical extract necessary for health can be either greatly reduced in amount or given up altogether. Unfortunately the diet is apt to be unattractive and lacking in variety. The tables prepared by Miss M. Abrahams, late Dietitian at St. Bartholomew's Hospital, and her colleagues, are very useful in arranging a diet and should enable patients to get the variety which they need. In a recent case (under the care of G. G.) the blood potassium decreased from 24 to 18 milligrammes when 10 grammes of sodium chloride was given; kept at 18 milligrammes with the use of salt and 10 c.c. of cortical extract, and decreased from 18 milligrammes to 13·5 milligrammes when a diet containing 1·5 grammes only of potassium was given, although no cortical extract was given.

The potassium-poor high-sodium diets must be used with caution when desoxycorticosterone, one of the active principles extracted from the adrenal cortex, is used either by injection or by implantation of a pellet. The general condition usually improves greatly, the blood chemistry becomes normal but some œdema of the legs may develop and the blood pressure may rise. In some of these cases death may occur very suddenly at the very moment that the prognosis seems especially good. It is believed that the low potassium in the blood plays some part and it seems wiser not to prescribe a low potassium diet when desoxycorticosterone is being given, but to restrict its use to the mild cases which do not need any injections of cortical extracts.[3, 4]

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[1] Loeb, R. F. (1932), *Science*, **76**, 420.

[2] Wilder, R. M., Snell, A. M., Kehler, E. J., Rynearson, E. H., Adams, M., and Kendal, E. C. (1936), *Proc. Mayo Clinic*, **11**, 273.

[3] Kuhlman, D., Ragan, C., Ferrebee, J. W., Atchley, D. W., and Loeb, R. F. (1939), *Science*, **90**, 496.

[4] Tooke, T. B., Power, M. H., and Kepler, E. J. (1940), *Proc. Mayo Clinic*, 365.

THE POTASSIUM-POOR DIET CONTAINING 1·50 GRAMMES OF POTASSIU

	Potassium (grammes)
BREAKFAST.	
2 oz. white bread	0·10
1 egg	0·07
1¾ oz. raw apple, or other fruit, amount in list (or containing 0·05 gramme K)	0·05
2 oz. milk in tea or coffee	0·10
DINNER.	
3 oz. roast beef, mutton, pork, steamed or fried cod, or steamed plaice, or six times any other meat or fish in the list	0·30
2 oz. carrots, or marrow, or other vegetables, amount in list (or containing 0·05 gramme K)	0·05
2⅔ oz. potatoes cut very small and cooked in eight times their volume of water	0·10
6 oz. stewed apples, or 5 oz. stewed pears, or other fruit, twice amount in list (or containing 0·10 gramme K)	0·10
¾ oz. cheddar cheese and ⅝ oz. sweet or water biscuit *or* ¾ oz. cereal and 1 oz. cream as pudding (cereal cooked in water with sugar, and cream added before serving)	0·05
TEA.	
2 oz. white bread	0·10
1¼ oz. jam or 1 oz. lettuce or ½ oz. tomatoes	0·05
2 oz. milk in tea	0·10
SUPPER.	
1½ oz. white bread, or ⅝ oz. biscuits, not digestive	0·07
1½ oz. salmon or haddock or chicken, or 3 oz. stewed beef or boiled mutton, or three times meat or fish in list	0·15
2 oz. orange, or other fruit, twice amount in list (or containing 0·10 gramme K)	0·10
2½ oz. butter all day	0·01
	1·50

Sugar or glucose, butter, suet, and salt may be taken as desired.

Ordinary gravy and the water from cooked fruit or vegetables must not be used.

Special gravy may be made with cornflour and water, coloured with browning and salted.

PORTIONS OF CARBOHYDRATE FOODS CONTAINING 50 MILLIGRAMMES OF POTASSIUM

(A) Vegetables. Cooked in the usual way

	oz.		oz.
Asparagus, boiled	2	Brussels sprouts	¾
Broad beans, boiled	¾	Cabbage, boiled	1¼
Beans, French or runner	1¾	Carrots, boiled	2
Beetroot, boiled	½	Cauliflower, boiled	1

(A) Vegetables. Cooked in the usual way—continued

	oz.		oz.
Celery, boiled	1¼	Peas, dried, boiled	¾
Celery, raw	½	Potatoes, old, boiled	⅓
Cucumber, raw	1¼	Potatoes, new, boiled	½
Leeks, boiled	½	Radishes	¾
Lentils, raw weight	¼	Spinach, cooked without water	¼
Lettuce	¾	Spring greens, boiled	1½
Marrow	2	Swedes, boiled	1½
Onions, boiled	2¼	Tomatoes	½
Onions, spring, raw	¾	Turnips	1
Parsnips, boiled	¾	Watercress, raw	½
Peas, fresh, boiled	1		

Vegetables. Cut very finely and cooked in eight times their volume of water

	oz.		oz.
Asparagus	2⅓	Parsnips	1⅓
Cabbage	1⅓	Peas, fresh or tinned	1⅓
Carrots	2⅓	Potatoes	1⅓
Cauliflower	1⅓	String beans	1⅓
Onions	2⅓	Turnips	2⅓

(B) Fruits

	oz.		oz.
Apricots, dried, stewed	⅕	Lemon-juice	1¼
Apricots, raw, fresh	⅔	Melon, cantaloupe or yellow	¾
Apples, raw, eating	1¾	Orange or orange-juice	1
Bananas	½	Peach, fresh, raw	¾
Blackberries, stewed	1½	Peach, dried, stewed	½
Blackcurrants, stewed	¾	Pears, raw, eating	1¾
Cherries, raw	¾	Pears, stewed	2½
Cherries, stewed	1½	Pineapple, raw	¾
Currants, dried	¼	Plums, raw dessert, or stewed	1
Damsons, raw	¾	Prunes	½
Damsons, stewed	1	Raisins, dried	¼
Green figs	¾	Raspberries, raw	¾
Gooseberries, ripe, raw	1	Raspberries, stewed	1¼
Gooseberries, unripe, stewed	1½	Red currants, raw or stewed	¾
Grapes	¾	Rhubarb, stewed	½
Grapefruit	¾	Strawberries, raw	1
Greengages, raw	½	Sultanas, dried	¼
Greengages, stewed	1	Tomatoes, raw	½

(C) Nuts

	oz.		oz.
Almonds	¼	Cobnuts	½
Barcelonas	¼	Desiccated coco-nut	¼
Brazils	¼	Peanuts	¼
Chestnuts	¼	Walnuts	¼

The above fruits are weighed with their stones if they are usually served with them.

(*D*) *Starchy Foods*

	oz.		oz.
Biscuits, sweet or water	1¼	Flour	1¼
Biscuits, digestive	½	Oatmeal, or Quaker Oats, raw weight	½
Biscuits, cream crackers	1¼	Rice, raw weight	1½
Bread, brown	½	Rusks	¾
Bread, white	1	Tapioca	10
Cornflour	2¾		

(*E*) *Sugar Rich Foods*

	oz.		oz.
Chocolate, plain or milk	⅓	Honey	3¼
Cocoa	¼	Jam	1¼
Golden Syrup	¾	Marmalade	4

PORTIONS OF PROTEIN AND FAT CONTAINING 50 MILLIGRAMMES OF POTASSIUM

	oz.		oz.
Bacon, raw weight	¾	Lobster, boiled	¾
Beef, corned	1½	Milk, fresh, whole	1
Beef, roast or salt, boiled	½	Milk, evaporated, sweetened or unsweetened	¾
Beef, stewed	1	Milk, skimmed, sweetened, condensed	⅓
Butter	12	Mutton, boiled	¾
Cheese, cream	4	Mutton, roast	½
Cheese, cheddar	1½	Mutton neck, stewed	1
Cheese, soft	2	Plaice, steamed	½
Chicken, boiled or roast	½	Pork, roast, or salt, boiled	½
Cod, steamed or fried	½	Rabbit	¾
Crab, boiled	¾	Salmon, fresh steamed or tinned	½
Cream, 50 per cent.	1¾	Sardines, tinned	⅓
Egg (one contains about 70 milligrammes of Potassium)		Sole, steamed	¾
Haddock, fresh or dried, steamed	½	Sweetbreads	¾
Hake	½	Tripe, stewed	16
Ham, lean, boiled	1⅓	Veal, roast	½
Kidney, stewed ox	1		

FOODS CONTAINING NEGLIGIBLE AMOUNTS OF, OR NO, POTASSIUM

Sugar, glucose, lactose
Butter, suet
Tapioca
Tripe

SOUR MILK TREATMENT

Curdled milk has long entered into the diet of many countries in the Near East (e.g. Roumania, Bulgaria, the Caucasus), and owing to the vivacious advocacy of Metchnikoff it had an enormous vogue in this country in the early years of this century. Soured milk therapy is still practised and has some advantages in treatment of dyspepsia.

The theory of its use is that the milk-souring bacilli antagonize the growth of the putrefactive bacilli and so, if established in the large intestine, prevent the production of histamine, tyramine, indol, and phenol in that part of the body. Metchnikoff assumed without sufficient evidence that the products of putrefaction shortened life.[1]

The " fermentation " of milks [2] in their country of origin is used to preserve the milk, and to make a pleasant and " stimulating " comestible. Yeasts and lactic acid bacilli are used for this purpose. Of the bacilli the strains utilized are the *Bacillus bulgaricus* (Metchnikoff), which occurs naturally in the cow, the *Bacillus acidophilus* found in man, and the *Bacillus bifidus* found in the alimentary tract of the infant. The differences are very slight but the *Bacillus bulgaricus* is more resistant and more active. Cultures of lactic-acid-producing microbes (usually cocci) are utilized in the souring of milk for the production of margarine.

The intention of the use of soured milk in medicine is (1) to change the flora of the large intestine, and (2) to produce an easily digested milk. Of the two reasons the latter is the more important, for the curds are smaller and softer than those normally produced in digestion of whole milk. It is not possible to change the flora of the intestine merely by feeding cultures by the mouth, but excess of lactose in the diet will encourage the growth of lactic-acid-producing microbes in the large intestine, even in the absence of soured milk or artificial cultures taken via the mouth.

Commercial preparations of the lactic acid bacilli are put up in the form of tablets and ampoules. Both contain negligible quantities of living bacilli if taken by the mouth but can be used as " starters " in building up a culture.

The Preparation of Acidophilus Milk. (i) ***From whole milk.*** Boil the milk and cool it to about 42° C. Inoculate the milk with 1 tablet of a good commercial culture and keep it either in a thermostat at 42° C. or in a thermos flask at this temperature for about 24 hours. Subculture it daily by adding two to three tablespoonfuls to freshly boiled milk when its temperature has fallen to about 24° C. It takes about a week before a sufficiently good culture is obtained and the milk curdles in about 12 hours. The curdled milk can either be eaten at once or placed in a refrigerator until it is wanted.

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[1] METCHNIKOFF. (1907), *The Prolongation of Life*, 16.

[2] For the account of these products the authors are indebted to Dr. Cuthbert Dukes.

(ii) ***From unsweetened condensed milk.*** Pour the milk into a scalded pan. Wash out the tin with an equal quantity of boiling water and add it to the condensed milk. Allow it to cool as above and add the commercial culture.

Commercial Preparations of Soured Milk. ***Kéfir.*** An effervescent soured milk prepared in its country of origin from cow's, goat's, or sheep's milk. Kéfir "grains" are used. These are masses of yeasts, moulds, and lactic-acid-producing bacilli. These are inoculated into the milk, which is kept in large leather bottles which are kept warm and shaken periodically. This soured milk contains 1 per cent. lactic acid and 2 per cent. alcohol.

It is prepared in this country by adding Kéfir grains (obtainable from the Lister Institute) and commercial strains of lactic acid organisms to pasteurized milk kept at room temperature for 12 hours. The resulting fluid is strained and fermented for 24 hours at 12–15° C. The higher the temperature the more alcohol and the lower the more lactic acid is formed.

Koumiss is fermented mare's milk.

Yoghourt. The countries of origin are the Balkan States. It is made from cow's or sheep's milk, boiled to half its volume, cooled and inoculated with some of the previous preparation as a starter. It consists of a semi-solid creamy substance containing 2–3 per cent. lactic acid and bacilli of the Bulgaricus strain plus streptococci. There is no alcohol in this preparation.

Sundry dairy firms will carry out the production of Kéfir and Yoghourt in this country.

The value of soured milk as a therapeutic agent is somewhat doubtful, but it has been recommended in cases of chronic ill-health without obvious cause, in neurasthenia and intestinal affections—e.g. colitis, fermentative diarrhœa, constipation—besides gout, arterio-sclerosis, and some skin diseases. As regards many of these affections it may be pointed out that there is little or no proof that they are really the result of intestinal putrefaction, and any improvement which soured milk may produce in them is probably to be ascribed to the fact that it provides an easily-digested form of food and so improves the patient's nutrition. In cases of hyperchlorhydria and chronic gastritis soured milk is contra-indicated.

CHAPTER XXIV

ARTIFICIAL FEEDING AND ARTIFICIAL AND PREDIGESTED FOODS

In this chapter we shall consider the methods of administering food otherwise than by the mouth, and describe some patent and artificial foods not yet dealt with.

Artificial Feeding

Rectal Feeding and Nutrient Enemata

Rectal feeding has constituted a therapeutic resource ever since medical science existed,[1] but it is only within recent times that the value of this method of administering nourishment has been subjected to careful scientific scrutiny.

Water is readily absorbed in the form of tap water. It is best given by a continuous rectal drip at the rate of 125 c.c. per hour and 3000 c.c. can be given in the 24 hours if nothing is taken by mouth. Normal physiological saline or Ringer's solution are not well tolerated as the salt irritates the mucous membrane so that they soon cease to be absorbed. In any case if 3000 c.c. were given in the day it would entail the giving of 27 grammes of sodium chloride which would be too much for the kidney to excrete. If one-fifth normal physiological solutions are used they are much better retained and the total salt administered in 3000 c.c. is 5·4 grammes, which the kidney should be able to excrete easily. One-third normal physiological solutions are also used and 3000 c.c. would mean the excretion of 9 grammes of sodium chloride.

Carbohydrates. Glucose is the only sugar which can be absorbed from the large intestine. If used in a high concentration it irritates the mucous membrane and is rejected after a while. Mutch and Ryffel [2] found that a 6 per cent. solution was well tolerated and this can be given either in tap water or one-fifth normal physiological saline as a rectal drip at the maximum rate of 125 c.c. per hour, or 3000 c.c. per 24 hours if nothing else is taken by mouth or intravenously. In this way 180 grammes of glucose can be administered and supply 738 Calories.

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[1] For a sketch of the history of the subject, see the valuable monograph by A. P. Gros, *Traitement de certaines Maladies de l'Estomac par la Cure de Repos absolu*, etc., Paris, 1898.

[2] Mutch, N., and Ryffel, J. H. (1913), *Brit. Med. Journ.*, 1, 111.

While the evidence is in favour of the absorption of glucose alone of the sugars from the solutions given per rectum (Tallerman),[1] it is not clear whether the sugar is absorbed from the large intestine or whether it must pass into the small intestine before absorption can take place. Davidson and Garry [2] have shown that practically no absorption of glucose or of any mono-saccharide takes place from the large intestine and cæcum of the rat. When, however, sugar was injected into the small intestine of the rat under the same conditions of anæsthesia, etc., a large proportion of the sugar was absorbed.

Proteins. The absorptive power of the large intestine for proteins has been investigated many times and it was thought by earlier workers that substances like peptone, eggs with salt, raw beef-juice were well absorbed, but later observations tend to throw much doubt upon the trustworthiness of the earlier experiments upon the absorption of proteins from nutrient enemata. Rendle Short and Bywaters, for instance, who reinvestigated the whole subject, came to these conclusions:

1. The older observations on the absorption of foodstuffs from rectal enemata, based on the analysis of rectal " wash-outs," are unreliable.
2. The daily output of nitrogen in the urine of patients given nutrient enemata of milk or eggs peptonized for twenty or thirty minutes demonstrates that almost no nitrogenous matter is absorbed.
3. Modern physiological opinion holds that proteins are absorbed principally as amino-acids. The failure of the rectum to absorb ordinary nutrient enemata is largely due to the fact that peptones are given instead of amino-acids.
4. Chemically prepared amino-acids, or milk pancreatized for 24 hours so that amino-acids are separated, allows of a much better absorption of nitrogenous foodstuffs from the rectum, as demonstrated in five cases by the high nitrogen output in the urine.
5. The low output of ammonia nitrogen shows that this high output was not due to the absorption of putrefactive bodies. The rectal washings were not offensive.

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[1] TALLERMAN. (1920), *Quart. Journ. Med.*, **13**, 356.

[2] DAVIDSON, J. N., and GARRY, R. G. (1939), *Journ. Physiol.*, 96, 172.

A practical disadvantage of the old nutrient enemata was the amount of putrefaction which occurred in the bowel and the most offensive smell which was noticed when the bowels were opened. These observations, which have been fully confirmed, are so striking that nutrient enemata containing protein which has not been well digested with pancreatic juice in order to liberate the amino-acids should not be used, and all details of such nutrient enemata are omitted in this section.

Peptonized Milk Enema

Boil 1½ pints of milk in flask, cool to 37° C.
Add ½ oz. of an active pancreatic preparation.
1½ oz. of glucose.
Keep at 37° C. for 24 hours.
Give 5–7 oz. every four hours.
A daily rectal washout should be given.

The value of this nutrient enema is very doubtful and other methods of feeding are much better.

Fats. These have been given as a suspension, but there is little evidence that they are absorbed and they should not be given.

Nutrient suppositories cannot be recommended. They usually contain peptone, but at most not more than 8 grammes in each, which means, even assuming complete absorption, an energy value of less than 35 Calories. The value of such suppositories is negligible.

Intravenous Feeding

Water, Sugar and Salt. These are best administered by the intravenous route if a patient cannot take anything by mouth. For a short infusion the vein may be pierced by a fine needle, but for a long infusion, one to three days, it is better to cut down on a small vein and tie in a canula. The antecubital veins should not be used except in emergency as it is very uncomfortable for the patient to keep his arm quite still. A cannula should never be tied into this vein as this will destroy it completely.

If after an abdominal operation a patient can take nothing by mouth he should be given a five per cent. glucose solution either in normal physiological saline or Ringer's solution, followed by 2000 c.c. of one fifth normal physiological saline or Ringer's solution containing five per cent. of glucose. If nothing is given by mouth, this amount of fluid is well tolerated and will contain 150 grammes of glucose supplying 615 Calories and 12·6 grammes of sodium chloride.

This procedure can be continued for one to two weeks, and the patients can be kept quite comfortable as they do not suffer from lack of fluid or sodium chloride. The caloric value is low, 615 Calories, and the patients will lose about 5 to 7 grammes of nitrogen a day which must come from the breakdown of muscle protein, and will also lose a good deal of fat (see p. 605).

If it is given for more than two days at least 25 milligrammes of ascorbic acid should be added to the perfusion fluid. If the patient had not been saturated with ascorbic acid before the operation, at least 1000 milligrammes a day should be given for three days in order to ensure the healing of the wounds.

On physiological grounds it would seem preferable to use Ringer's solution in order to supply calcium and potassium in addition, which are essential for life. This is a little more complicated to prepare than normal saline. If, however, the sodium bicarbonate is omitted it is just as easy to sterilize as normal saline. It is, however, little if at all used by the medical profession. This may be due to three causes :

(1) The initial difficulty of preparing a stable solution, which prevented its use originally.

(2) It is not as a rule provided.

(3) The innate conservatism of the surgeons who chiefly use these solutions.

Amino-acids. Protein hydrolysates in intravenous alimentation.

Various attempts have been made to give patients sufficient food to maintain life at a high level by intravenous methods. These have been successful in the hands of research workers and may soon be available for ordinary use and a short account of the work is given here. The proteins have been digested either by hydrolysation with acids, alkalis, or with enzymes. The disadvantage of the acid hydrolysation of casein is that tryptophane is destroyed in the preparation and it together with methionine and cystine must be added. The alkaline hydrolysate preserves the tryptophane but destroys the methionine and cystine and a mixture of acid and alkaline hydrolysates has been advocated, but its trial has not yet been reported. Digestion with enzymes like trypsin or papain or with a mixture (Beattie) has been used. These have the advantage that the amino-acids are not destroyed but the digestion takes several days instead of a few hours and sterility of the mixture is difficult to maintain.

Technique. A solution of protein hydrolysate plus 10 per cent. glucose is made up in cold freshly distilled water and passed through a Berkefield filter autoclaved for 30 minutes at 5 lb. pressure (Elman, 1940). This is injected into a vein at a rate 300–500 c.c. an hour.

As much as 3000 c.c. in the 24 hours containing 75 grammes of protein hydrolysate and 300 grammes of glucose (Calories 1537) have been given and this has been maintained for 23 days by Elman.[1] It is possible in this way to maintain the body in nitrogen equilibrium and in weight. Taylor [2] (1943) gave much larger doses—200 grammes of the protein hydrolysate together with 300 grammes of protein by mouth to a patient who was very ill with extensive burns. The treatment was continued for over 40 days and the patient, who at the outset seemed likely to die, recovered.

The injections have been responsible for reactions like flushing and burning of the skin, headache, backache, rigors, abdominal pain, nausea, vomiting, phlebitis and thrombosis. These are probably due to some impurities and may cease as the method of preparation improves.

Examination of patients who have died during the course of treatment showed that the hydrolysate was not responsible for any of the deaths.

The protein hydrolysates have been used for patients with malignant disease of the œsophagus, stomach and ulcerative colitis and it was usually possible to maintain nitrogen equilibrium. If, however, the output of nitrogen was very large, as occurs after operations, it was not possible to attain nitrogen equilibrium. (Elman, 1939, 1940).

Good results have been obtained in patients with severe burns.[2] The results with dysentery and severe ulcerative colitis are good, but those with liver diseases are conflicting. Alstruter *et al*,[3] 1942, thought they were contra-indicated, but Landesman and Weinstein,[4] Stewart and Rourke,[5] found that the patients used the digests and often with benefit. They are also of value in promoting the regeneration of plasma proteins after hæmorrhage and it was found that cystine was of greater value than methionine, which is not present in horse serum albumen.[6]

The possibilities opened up by this method of intravenous feeding are very great. It is to be hoped that the preparation will soon be readily available as this may well turn the scale with many very ill patients who at present receive intravenous therapy with sugar, salt and water only.

They should be useful in the treatment of patients with malnutrition, but the evidence at present suggests that plasma given intravenously to begin with is more useful for the very ill patients.

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[1] ELMAN and LISCHER. (1943), *Ann. Surgery*, **118**, 225.

[2] TAYLOR *et al.* (1943), *Ann. Surgery*, **118**, 215.

[3] ALTSTRUTER and TAYLOR. (1943), *Arch. Inst. Med.*, **70**, 749.

[4] LANDESMAN and WEINSTEIN. (1942), *Surg. Gyn. Obst.*, **75**, 300.

[5] STEWART and ROURKE. (1942), *Proc. Soc. Exp. Biol. Med.*, **51**, 369.

[6] BRAND and KASSELL. (1941), *J. Bio. Chem.*, **141**, 999.

SUBCUTANEOUS FEEDING

The injection of nutritive substances under the skin was first introduced by Menzel and Perco in the year 1869,[1] and is now very little used as this has been replaced by the intravenous route. Sugar and salt may be given subcutaneously in the same quantities as for intravenous infusions if these cannot be performed and the patient cannot take anything by mouth or by the rectum.

Artificial Foods

The objects of artificial foods may be said to be either (1) to present a maximum of nourishment in a minimum of bulk, or (2) to enable one easily to enrich the diet in respect of certain of its chemical constituents.

In regard to the former of these objects, it is well to realize at the outset what *degree of concentration of food* is chemically possible. Let us take first the case of the ***proteins.*** Lean meat may be regarded as the type of a natural protein food. It contains about one-fifth of its weight of that constituent, the rest being chiefly made up of water. If all the water is driven off from 5 oz. of meat, there will be left behind about an ounce of what is practically pure protein. Now, this may be regarded as the maximum degree of concentration of which protein food is capable. In other words, an ounce of any artificial protein food can never represent more than 5 oz. of lean meat. A more concentrated protein food than that is a chemical impossibility. We can realize from this the absurdity of such preparations as beef-lozenges. Even if these did consist of pure protein (which they never do), it would require 1 oz. of them at least to be equal in food value to 5 oz. of fresh meat, so that the amount of nutriment contained in one lozenge must be very small indeed.

Or take, again, the case of the ***carbohydrates.*** There is no form of carbohydrate food more concentrated than sugar. Any fluid or semi-fluid carbohydrate preparation must inevitably be of lower nutritive value than sugar, for it contains some water, the food value of which is nil. Such preparations as malt-extracts, therefore, can never add to the diet as much carbohydrate as an equal weight of ordinary sugar.

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[1] For the history of subcutaneous feeding, see BAUER, "The Dietary of the Sick" (Von Ziemssen's *Handbook of General Therapeutics*, 1, 271), and LEUBE in LEYDEN'S *Handbuch der Ernährungstherapie*, 1, 513.

The same is true of *fats*. No artificial preparation can have a higher food value than pure olive-oil, which contains no water, or dripping, from which all the water has been driven off by heat. Ordinary butter contains four-fifths of its weight of pure fat.

There are, then, distinct limits beyond which the concentration of foods cannot be carried, and the idea that " food tabloids " might be prepared, one or two of which would be the equivalent of an ordinary meal, is seen to be an impossible dream. At the most, all that the maker of concentrated artificial foods can hope to do is to drive off from the natural food the excess of water which it contains, and even then most, if not all, of the original water must be returned to the food before it can be eaten.

It may be questioned, too, ***whether the use of highly concentrated foods is physiologically defensible.*** The digestive organs are not constructed for the disposal of foods in an extremely compact form. Such forms of nutriment make large demands upon the secretory powers of the stomach, and are apt to be irritating to the digestive organs, in addition to which the total absence in them of " ballast " renders them unable to supply an adequate stimulus to the peristaltic movements of the intestines. As exclusive foods, therefore, such preparations are eminently unsuitable.

The second object of these substances, that of enabling us to ***enrich the diet in certain ingredients,*** is more legitimate. Here the artificial food is used simply as an accessory to supplement the lack of protein, carbohydrate, or fat in other articles of diet. Their small bulk is here a decided advantage, for it enables them to be added to fluid foods without appreciably increasing the total amount of material to be swallowed, and in many cases of illness this is a desirable thing to do.

We may conclude, then, that concentrated foods are only to be used as accessories, and that they have no legitimate place in the dietary of health.

In cases of illness, however, they have a definite but limited sphere of action. In these circumstances, when appetite is in abeyance, it is often a question not so much of getting the patient to take much nourishment as of persuading him to eat at all. It is then that the artificial foods serve a useful purpose, for they can be varied to suit the caprices of the patient, and though the amount of actual nourishment which they yield may be small, they may yet kindle a desire for ordinary foods. The value of any artificial preparation in such a case is not to be estimated by the amount of energy it yields, so much as by its æsthetic qualities and the degree to which it pleases the patient. Suggestion, in fact, plays a large part in bringing about whatever good results artificial foods are capable of producing.

ARTIFICIAL PROTEIN FOODS

1. **Undigested**—(*a*) ***Of Animal Origin.*** Probably the best of the undigested protein foods are now derived from casein, the chief protein of milk. In a previous chapter most of these, e.g. Plasmon and Casumen, have been described. They have the advantage of being colourless, tasteless, and readily soluble, so that they can easily be added to other foods, besides which they are digested without difficulty and are very completely absorbed.

Of the artificial protein foods derived from meat, most belong to the predigested class to be considered immediately. The "dehydrated" meats or fish are usually soaked in water before serving and so regain all the water which was removed in its preparation. Although very palatable and making excellent mince or ketcheree, they can hardly be described as concentrated foods.

Dried milk is a concentrated food and can be added to any drink to thicken it. Dry skim milk can be added to milk.

(*b*) ***Of Vegetable Origin.*** The chief vegetable protein foods are ***Aleuronat, Legumin, and Glidine.***[1] The first is a special preparation of gluten containing 81·6 per cent. of protein. It is a yellowish-brown powder, almost insoluble in water, and can be conveniently used as an addition to semi-solid foods.

Legumin (vegetable casein) is the chief protein of pulses, and is a valuable and highly nutritive substance, apt, however, to have a rather bitter taste.

Glidine is prepared from wheat protein and contains 95 per cent. protein. It is easily soluble and can be added to any foods.

2. **Digested Protein Foods or Peptone Preparations.** These had at one time a considerable vogue in dietetics. The proteins are partially broken down in the normal stomach to peptones and albumoses (p. 238). If these products are given to a healthy person they are further broken down in the course of digestion to polypeptides and amino-acids in the same way as the original proteins, and are therefore capable of replacing them. Their use should relieve the stomach of some of the preliminary work of digestion. In practice this is of little value as the stomach and intestines are rarely so damaged that they are unable to digest the protein of eggs and milk. Further, these products are liable to cause diarrhœa for some unknown reason if given in large amounts, but are well tolerated in small quantities.

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[1] Many of the preparations are at present unobtainable.

The following tables contain analyses of some of the semi-solid and liquid peptone preparations.

Most of these contain so much water that their nutritive value is comparatively small, while those in which alcohol is present are open to the same objections as dietetic or medicinal wines (see p. 517).

COMPOSITION OF PEPTONE PREPARATIONS

	Water.	Insoluble Protein.	Soluble Proteins, chiefly Albumoses.	Extractives.	Carbohydrate.	Fat.	Inorganic Constituents.	Alcohol.
Peptonized Milk . .	87·5	—	1·76	—	10%	3·3	?	—
Fairchild's Panopepton	81	—	6·5	?	16·5%	—	1·0	18·5%
Benger's Peptonized Meat Jelly . .	89·68	—	7·16	2·27	—	—	0·89	—
Somatose . .	59	—	17	4	—	—	4	—
Peptalac (Cow and Gate) .	87·9	—	4·2	—	6·2%	0·9	0·8	—
Carnrick's Peptonoids .	—	—	38·8	—	48%	—	8%	—

Home-made peptonized foods can easily be prepared with such agents as liquor pancreaticus or zymine (see p. 687). Milk which has been peptonized in this way is still used, though many doubt its value.

Gruels of various sorts can be prepared in a similar way, peptonized milk gruel being one of the best. Such home-made preparations are mostly to be preferred to commercial articles, and have also the advantage of being very much cheaper.

ARTIFICIAL CARBOHYDRATE FOODS

Many patent foods which might justly be included in this section have been already dealt with under the cereals, pulses, etc., or in the section on Infant Foods. The only group which remains to be considered is that of the ***malt-extracts.*** These are prepared by evaporating down an infusion of malted barley at low temperatures or *in vacuo.* The object of evaporating them in that way is to preserve in an active form the diastatic ferment present in the malt; and the special apparatus required for this purpose is one cause of the expense of such preparations.

The following table contains the results of the analyses of some standard malt-extracts:

COMPOSITION OF MALT-EXTRACTS

	Total Solids.	Reducing Sugars as Maltose.	Protein.	Dextrin.	Ash.	Alcohol.	Diastatic Power Lintner Units.
Kepler Extract of Malt	78·5	65·5	5·5	6·2	1·3	—	900–1000
D.C.L. Malt-Extract	81·1	?	6·82	?	1·11	—	60
Cream of Malt	79·4	62·6	6·5	8·2	1·4	—	40
Standard Malt-Extract	79·4	60·3	6·5	10·5	1·4	—	30–40
Standard Liquid Malt-Extract	53·5	40·4	4·35	6·8	0·9	9·0	19–26
Extract of Malt	80	50·5	5·2	—	1·2	—	—
Bynin	63·4	59·6	3·2	—	0·9	8·3	—
Maltine	78	61·9	6·0	5·0	1·2		1000

The average value of these foods is 57 grammes of sugar, 5·8 grammes of protein, 6·3 grammes of dextrin, and the caloric value is 283 per 100 grammes. 1 oz. yields about 80 Calories, or a little more than one egg. The diastatic value is low except in the Kepler Extract of Malt.

In the above analyses the whole of the nitrogenous matter has been counted as protein, but it is very doubtful if that is quite accurate. Some of the nitrogen is almost certainly present in other forms.

Malt-extracts may be prescribed with one of two objects : (1) To enrich the supply of carbohydrates in the diet ; (2) to aid the digestion of starchy foods by means of the diastase which the extract contains. The advantages possessed by malt-extracts for accomplishing the former of these objects are not quite apparent. ***Treacle and golden syrup*** both contain a considerably higher percentage of sugar, and are vastly cheaper. It is true that malt-sugar is less apt to irritate the stomach than the cane-sugar which treacle and syrup contain, and although not capable of direct absorption as such, maltose may yet be regarded as a partially digested form of carbohydrate. But in both these respects we have in ordinary honey a superior food.

Honey has the following composition :

Water	16 to 13	per cent.
Invert sugar	71·4	,,
Cane-sugar	2·69	,,
Protein	0·4	,,
Ash	0·12	,,

That is to say that it is actually richer in sugar than malt-extract, but has less protein and no dextrin ; the caloric value of 1 oz. is 104. Furthermore, the sugar of honey is really in a predigested form, and ready for immediate assimilation. As a source of carbohydrate, therefore, honey is in every way preferable to malt-extracts, besides being a good deal cheaper ; and it may be used with great advantage in every case in which one wishes to supplement the supply of carbohydrates in the diet.

The second property of malt-extracts—that of acting upon starch by means of the diastase which they contain—is but rarely present in the mind of the prescriber. The cases in which such an action is desired are not, indeed, at all numerous, and are practically confined to the group of so-called amylaceous dyspepsias. Even in such a case malt-extract is not the best preparation to employ. No matter how carefully the extract may be prepared, it always seems to lose something of its diastatic power in the process ; and it is far more certain, as well as cheaper, and one may add pleasanter, to make an infusion of malt at home, and either use it as a beverage at meals, or, preferably, stir it into starchy foods, such as puddings or gruel, before they are eaten.

The value of ***milk-sugar*** as a means of supplementing the carbohydrates of the diet must not be forgotten. Its comparative freedom from sweetness makes it specially suitable for such a purpose. If ½ oz. of it is dissolved in 5 or 6 oz. of milk, the nutritive value of the latter is increased by nearly 60 Calories. This may often be taken advantage of in feeding patients with acute fevers. As explained above it can be used to depress the activity of putrefactive organisms in the large intestine.

The number of preparations used in medicine which contain the various vitamins either alone or in combinations, is getting very large, and it is important that their content should be known.

By the courtesy of the Editor of *The Pharmaceutical Journal* a list of commercial preparations containing vitamins appeared in the 1940 edition of this book. This was compiled from information supplied or published by the manufacturers and was intended to serve as a guide to the nature, potency and source of the preparations listed. The particulars concerning the potencies of the preparations are the claims made by the manufacturers. No attempt was made by the *Pharmaceutical Journal* to verify them by actual tests on the products themselves.

The list is now brought up to date by the *Pharmaceutical Journal*, 1944, and printed with slight alterations.

Name of Preparation.	Description.	Makers.
	Vitamin A	
Alphalin . . .	Capsules, 10,000 I.U. per capsule .	Lilly
Avoleum . .	Liquid, 30,000 I.U. per gm. Capsules, 4500 I.U. per capsule	B. D. H.
β-Carotene . .	Crystals, 1,600,000 I.U. per gm. .	Napp
Carotene Oil .	(1) 0·785 mg. α- and 1·54 mg. β-carotene representing 3195 I.U. A per gm. (2) 0·1 mg. α- and 0·068 mg. β-carotene representing 1210 I.U. A per gm.	Napp
Carotene "Tabloid"	2 mg. per "tabloid"	B. W.
Davitamon A .	6000 I.U. and 60,000 I.U. per mil. ampoules, 60,000 I.U. in 1 mil. oil solution	Organon
Essogen . . .	2000 I.U. per capsule. . . .	Lever
Fish Liver Oil .	Liquid, 200,000 I.U. per gm.. .	Napp
Prepalin . .	Liquid, 72,000 I.U. per mil. Capsules, 24,000 I.U. per capsule. Ampoules, 100,000 I.U. in 1 mil.	Glaxo
Vitamin A . .	Capsules, 33,000 I.U. per capsule. Ampoules, 100,000 I.U. in 1 mil.	Crookes
Vitapex Pabyrn	Capsules, 4500 I.U. per capsule. Ampoules, 75,000 I.U. per mil.	Paines & Byrne
	Vitamin B_1 (Aneurine)	
Befortiss . .	Ampoules, 5 mg., 10 mg. and 25 mg.	Vitamins, Ltd.
Benerva . .	Tablets, 1 mg. and 3 mg. per tablet. Ampoules, 5 mg. per ampoule. Ampoules Forte, 25 mg. per ampoule	Roche Products
Berin . . .	Ampoules, 5 and 25 mg. per ampoule. Tablets, 1 mg. and 3 mg. per tablet	Glaxo
Betaxan . .	Tablets, 1 mg. and 3 mg. per tablet. Ampoules 5 mg. and 25 mg. per mil. Solution 250 mg. in 10 mils. Elixir 0·675 mg. per drachm	Bayer
Betalin 1 Capsules	Capsules, 125 I.U. per capsule .	Lilly
Betalin S . .	Ampoules, 1 mg., 6 mg. 10 mg., and 30 mg. per ampoule. Tablets 0·1 mg., 3 mg. and 6 mg. per tablet	Lilly

Name of Preparation.	Description.	Makers.
Betebion . . .	Tablets, 1 mg. per tablet. Ampoules, 2 mg. in 1 mil. Ampoules "Strong," 10 mg. in 1 mil.	Merck
Crysto-Vibex .	Ampoules, 5 mg. and 25 mg. per mil. Solution 50 mg. per mil. Tablets, 1 mg. and 3 mg. per tablet	P. D. & Co.
Davitamon-B_1 .	Tablets, 1 mg. per tablet. Ampoules 5 mg. Forte Tablets 3 mg. per tablet. Ampoules 25 mg.	Organon Organon
Pulvis Vitamin B_1	(1) B.P. standard. (2) Double B.P. standard	Napp
Ryzamin-B . .	80 I.U. per gm.	B. W.
Thiamin Chloride	Tablets, 1 mg. and 3 mg. per tablet	Abbott
,, ,,	Elixir, 1800 I.U. per fluid ounce	Abbott
Vitamin B_1 .	Ampoules, 1·5 mg. and 3 mg. per ampoule. Tablets, 1·5 mg. and 3 mg. per tablet. Injection 1·5 and 3 mg.	A. & H
Vitamin B_1 .	Ampoules, 5 mg. and 25 mg. per mil. Tablets, 1 mg. and 3 mg. per tablet	B. D. H.
Vitamin B_1 . Hydrochloride	"Hypoloid," 5 mg. and 25 mg. in 1 mil. "Tabloid," 3 mg. and 5 mg. per "tabloid."	B. W.
Vitamin B_1 .	Ampoules, 5 mg. and 25 mg. per mil. Capsules, 1 mg. per capsule. Tablets, 1 mg. and 3 mg. per tablet.	Crookes Labs.
Vitamin B_1 "Pabyrn"	Ampoules, 5 mg. and 25 mg. per ampoule. Tablets, 1 mg. and 3 mg. per tablet.	Paines & Byrne
	Nicotinic Acid	
Davitamon-PP Nicotinic Acid	Tablets, 50 mg. per tablet . .	Organon
Nicotinic Acid .	Tablets, 50 mg. per tablet . .	Bayer
Nicotinic Acid .	Tablets, 50 mg. per tablet . .	P. D. & Co.
Nicotinic Acid .	Tablets, 50 mg. per tablet . .	A. & H.
Nicotinic Acid .	Tablets, 50 mg. and 100 mg. per tablet	B. D. H.
Nicotinic Acid .	"Hypoloid," 50 mg. in 1 mil. "Tabloid," 50 mg. per "tabloid"	B. W.

Name of Preparation.	Description.	Makers.
Nicotinic Acid .	Ampoules, 50 mg. per 2-mil ampoule. Tablets, 50 mg. per tablet	Crookes Labs
Nicotinic Acid .	Tablets, 20 mg., 50 mg. and 100 mg. per tablet	Lilly
Nicotinic Acid .	Tablets, 50 mg. per tablet . .	Roche
Nicotinic Acid .	Tablets, 25 mg. per tablet . .	Squibb
Pelonin (Nicotinic Acid)	Ampoules, 50 mg. per 2 mils. Tablets, 50 mg. per tablet	Glaxo
Nicotinamide .	Ampoules, 50 mg. Tablets, 50 mg. per tablet	B. D. H.
Nicotinamide .	Tablets, 50 mg. per tablet. Ampoules, 50 mg. per ampoule	Roche
	Vitamin B_2 (Riboflavine)	
Lactoflavine .	Ampoules, 1 mg. and 5 mg. per ampoule. Tablets, 1 mg. and 3 mg. per tablet	Roche Products
Riboflavine	Ampoules, 1 mg. in 2 mils. Tablets, 1 mg.	B. D. H.
Riboflavine . .	"Hypoloid," 1 mg. per 2 mil. "Tabloid," 1 mg. and 5 mg. per "tabloid"	B. W.
Riboflavine . .	Tablets, 1 mg. = 400 Sherman Units (G) per tablet	Lilly
Riboflavine B_2 .	Tablets, 1 mg. per tablet. Ampoules, 1 mg.	Crookes Labs.
	Vitamins B_1 and B_2 (Aneurine and Riboflavine)	
Benerva Compound	Tablets, 1 mg. B_1; 1 mg. riboflavine (B_2); 15 mg. nicotinamide	Roche
Betalin Compound	Capsules, 333 I.U. B_1, 40 Sherman units B_2 and other factors of B_2 complex per capsule	Lilly
B & G Capsules	Capsules, 67 I.U. B_1 and 0·04 mg. B_2 riboflavine per capsule	Squibb
B & G Syrup .	50 I.U. B_1 and 0·01 mg. B_2 riboflavine per mil.	Squibb

Name of Preparation.	Description.	Makers.
Marmite . .	30 I.U. B_1, 0·033 mg. B_2 and 0·64 mg. nicotinic acid per gm.	Marmite Food Extract Co.
Vitamin B Capsules	150 I.U. B_1 and 40 Sherman units B_2—(0·1 mg.) riboflavine per capsule	Abbott
Marmite . .	(Unstandardized) B_1, 8–10 I.U. per gm. (approx.), B_2, 0·033 mg. per gm. (approx.). Nicotinic acid, 0·64 mg. per gm. (approx.).	Marmite Food Co.
Vitamin B_1 Complex	(1) 100 I.U. B_1, and 0·1 mg. B_2 per gm. (2) 200 I.U. B_1, and 0·2 mg. B_2 per gm.	Napp
Yeast (Brewers')	Tablets, 15 I.U. B_1 and 20 Sherman units B_2—(0·05 mg.) riboflavine per tablet	Abbott
	Vitamin B_6 (Pyridoxin)	
Vitamin B_6 (Pyridoxin)	Ampoules, 50 mg. per 1 mil. Tablets, 10 mg. per tablet	Crookes Labs.
Pyridoxin . .	Ampoules, 50 mg. per ampoule. Tablets, 10 mg. per tablet	B. D. H.
Pyridoxin . .	Ampoules, 50 mg. per ampoule. Tablets, 10 mg. per tablet	Vitamins, Ltd.
	Vitamin C (Ascorbic Acid) 10 mg. = 200 I.U.	
Ascorbic Acid Tablets	50 mg. per tablet	Abbott
Ascorbic Acid .	Ampoules, 100 mg. and 500 mg. per ampoule. Tablets, 5 mg., 25 mg. and 50 mg. per tablet	A. & H.
Ascorbic Acid .	Tablets, 25 mg. and 50 mg. per tablet. Tablets, 5 mg. (Vitamin C for infants) per tablet. Ampoules, 100 mg. and 500 mg. per ampoule	B. D. H.
Ascorbic Acid .	"Tabloid," 5 mg., 25 mg. and 50 mg. per "tabloid"	B. W.
Ascorbic Acid .	Tablets, 50 mg. per tablet . .	Vitamins, Ltd.
Cantan . . .	Tablets, 5 mg., 25 mg. and 50 mg. per tablet. Ampoules, 100 mg. and 500 mg,	Bayer

Name of Preparation.	Description.	Makers.
Celin . . .	Ampoules, 100 mg. per 1 mil. Tablets, 5 mg. and 50 mg. per tablet	Glaxo
Cevalin . . .	5 mg. and 25 mg. per tablet .	Lilly
Davitamon-C .	Tablets, 5 mg. and 25 mg. per tablet. Ampoules, 50 mg. and 500 mg.	Organon
Planavit C . .	Tablets, 5 mg. and 50 mg. per tablet.	May & Baker
Redoxon . .	Tablets, 5 mg., 25 mg. and 50 mg. per tablet. Ampoules, 100 mg. and 500 mg.	Roche Products
Vitamin C . .	Ampoules, 100 mg. Tablets, 5 mg. and 50 mg.	Crookes Labs.
Vitamin C (" Pabyrn ")	Ampoules, 100 mg. and 500 mg. Tablets, 5 mg., 25 mg. and 50 mg. per tablet	Paines & Byrne
Vitamin C . .	Ampoules, 500 mg. Tablets, 25 mg. and 50 mg. per tablet	P. D. & Co.
	Concentrate, 43 mg. per gramme Black currant syrup, 70 mg. in 1 dr. Rose hip syrup, 200 mg. in 1 dr.	Napp
	Vitamin D	
Calciferol . .	"Tabloid," 0·1 mg. (4000 I.U.) and 0·25 mg. (10,000 I.U.) per "tabloid." "Wellcome" solution, 3000 I.U. per gm.	B. W.
Calcium with Vitamin D	250 I.U. per teaspoonful. Capsules, 250 I.U. per 3-min. capsule. Ampoules, 5000 I.U. per 1 mil	Crookes Labs.
Calcydic . .	1500 I.U. per drm. Tablets, 500 I.U. per tablet with dicalcium phosphate	A. & H.
Calfo-Rayol .	Tablets, 660 I.U. with 9 grains dicalcium phosphate and 6 grains calcium gluconate	Squibb
Calsimil . . .	Tablets, containing calcium sodium lactate 5 gr. with Vitamin D_2 500 I.U.	B. D. H.
Calsolact D Tablets	Tablets, calcium sodium lactate with 1000 I.U. of D per tablet	A. & H.
Colloidal Calcium with "Ostelin" (Vitamin D)	Injection, 5000 I.U. per mil . .	Glaxo
Davitamon-D .	Liquid, 5000 I.U. per mil, in oil solution	Organon

Name of Preparation.	Description.	Makers.
Davitamon-D Forte	Liquid, 12,500 I.U. per mil. Ampoules, 12,500 I.U. per mil	Organon
Davitamon-D Superforte	Liquid, 300,000 I.U. per mil. Ampoules, 300,000 I.U. per mil	Organon
Decufer . . .	Tablets, 500 I.U. with iron, copper and manganese	Organon
Ostelin . . .	Liquid, 5000 I.U. per mil . .	Glaxo
	Tablets, 500 I.U. and 50,000 I.U. per tablet. Emulsion, 100 I.U. per 3 fl. oz.	Glaxo
Ostocalcium .	Tablets, 500 I.U. per tablet . .	Glaxo
Radiostol . .	Solution, 3000 I.U., 100,000 I.U. and 200,000 I.U. per gm. Pellets, 3000 I.U. per pellet	B. D. H.
Viosterol. . .	Liquid, 15,000 I.U. per gm. . .	A. & H.
Vitamin D (" Pabyrn ")	Ampoules, 15,000 I.U. per mil. Tablets, 2000 I.U. per tablet	Paines & Byrne
	Vitamins A and D	
Adexolin . .	Liquid, 12,000 I.U. A, 2000 I.U. D. per mil. Capsules, 4500 I.U. A, 900 I.U. D per capsule	Glaxo
Advita . . .	2000 I.U. A, 200 I.U. D. per capsule	Lever Bros.
Bynol . . .	Liquid, 300 I.U. A, 40 I.U. D per gm.	A. & H.
Cod-Liver Oil Ointment	2500 I.U. A, 250 I.U. D per gm. .	A. & H.
Cod-Liver Oil, Perfected	Not less than 1200 I.U. A, 150–200 I.U. D per gm.	A. & H.
Cod-Liver Oil, Reinforced	2000 I.U. A, 500 I.U. D per mil .	May & Baker
Crookes' Emulsion	2000 I.U. A, 200 I.U. D per dr. .	Crookes Labs.
Davitamon A-D	Liquid 6000 I.U. A, 5000 I.U. D per mil. Capsules, 3000 I.U. A, 2000 I.U. D per capsule	Organon
Davitamon A-D Comfits	Comfits, 1500 I.U. A, 1000 I.U. D per comfit	Organon
Dekadexolin .	Ampoules, 60,000 I.U. A, 10,000 I.U. D per mil	Glaxo
Halibol . . .	Liquid, 40,000 I.U. A, 6500 I.U. D per gm. Capsules, 4500 I.U. A, 900 I.U. D per capsule	A. & H.

Name of Preparation.	Description.	Makers.
Halibol Calcium Capsules	4500 I.U. A, 900 I.U. D and 5 gr. calcium sodium lactate per capsule	A. & H.
Halibut-Liver Oil, Natural	Liquid, 40,000 I.U. A, 3000 I.U. D per gm. Capsules, 4500 I.U. A, 450 I.U. D per capsule	A & H.
Halibut-Liver Oil	(1) Liquid, 30,000 I.U. A, 2000 I.U. D per gm. (2) From 20,000 to 100,000 I.U. A, from 2,000 to 3000 I.U. D per gm.	Napp
Halibut-Liver Oil	Liquid 5200 I.U. A, 2500 I.U. D per gm. Capsules, 425 I.U. A, 8800 I.U. D per capsule	Crookes Labs.
Halidexol . .	Liquid, 5740 I.U. A, 382 I.U. D per dr.	Crookes Labs.
Haliver Oil . .	Capsules, 4500 I.U. A, 450 I.U. D per capsule. Liquid, 50,000 I.U. A, 850 I.U. D per gm.	Abbott
Haliverol . .	Liquid, 27,000 I.U. A, 5400 I.U. D per gm. Capsules, 4500 I.U. A, 900 I.U. D per capsule	P. D. & Co.
Hepicoleum .	Capsules, 4500 I.U. A, 1000 I.U. D per capsule	Lilly
Halycalcyne .	Capsules, 5330 I.U. A, 1063 I.U. D per capsule with calcium phosphate	Crookes Labs.
Minadex Syrup	600 I.U. A, 100 I.U. D, per mil. .	Glaxo
Nadola . . .	Liquid, 27,000 I.U. A, 2700 I.U. D per gm. Capsules, 4500 I.U. A, 450 I.U. D per capsule	P. D. & Co.
Navitol . . .	Liquid, 55,000 I.U. A, 10,000 I.U. D per gm. Capsules, 9400 I.U. A, 1700 I.U. D per capsule	Squibb
Oladol . . .	Liquid, 55,000 I.U. A, 5500 I.U. D per gm. Capsules, 6000 I.U. A, 600 I.U. D per capsule	Abbott
Radiostoleum .	Ampoules, 75,000 I.U. A, 15,000 I.U. D. Liquid, 15,000 I.U. A, 3000 I.U. D per gm. Capsules, 4500 I.U. A, 900 I.U. D per capsule	B. D. H.
Rayolex . . .	Tablets, 3300 I.U. A, 660 I.U. D per tablet	Squibb

Name of Preparation.	Description.	Makers.
"Seven Seas" High Potency Oil	2400 I.U. A, 340 I.U. D per gm.	British C.L.O. Producers
Super D Oil .	Liquid, 65,700 I.U. A, 52,000 I.U. D_3 per gm. Capsules, 11,000 I.U. A, 9000 I.U. D_3 per capsule	Crookes Labs.
Vitamin A and D	Capsules, 4500 I.U. A, 1000 I.U. D per capsule	Vitamins, Ltd.
Vitapan . . .	Capsules, 4500 I.U. A, 1000 I.U. D per capsule. Compound tablets, 1500 I.U. A and 300 I.U. D, with 1/40 grain parathyroid and calcium glycerophosphate	Paines & Byrne
	Vitamin E	
Davitamon-E .	Capsules, 0·5 ml. wheat-germ oil per capsule	Organon
Ephynal . .	Tablets, 3 mg. (*Racemic tocopheryl acetate*) and 20 mg. per tablet (3 I.U. per tablet)	Roche Products
Fertilol	Wheat-germ oil, 5 minims per capsule	Vitamins, Ltd.
Phytoferol . .	Capsules, equivalent 3 mg. dl. α-tocopherol per capsule	B. D. H.
Trigol . . .	Capsules, 5 minims of wheat-germ oil	Abbott
Vitamin E . .	Capsules, 3 mg. α-tocopherol per capsule	A. & H.
Vitamin E . .	"Tabloid," 3 mg. tocopherol per "tabloid"	B. W.
Vitamin E Germinol ("Pabyrn")	Capsules, each equivalent to 5 gm. wheat-germ oil	Paines & Byrne
Viteolin . . .	Capsules, 6 mg. of α-tocopherol per 3-minim capsule	Glaxo
Wheat-Germ Oil	1/3 mg. per 3-min. capsule .	Crookes Labs.
Wheat-Germ Oil	2 Evans-Burr U. per gm.	Lilly
	Vitamin K	
Davitamon K .	Liquid, 10 mg. acetomenaphthone per mil. oil solution. Tablets, 10 mg. per tablet. Ampoules, 10 mg. menaphthone per mil. oil solution	Organon

Name of Preparation.	Description.	Makers.
Kappaxan	Tablets, 10 mg. acetomenaphthone per tablet. Ampoules, 5 mg. menaphthone	Bayer
Kayvisyn	4-Amino - 2 - methyl - 1 - naphthol, 1 mg. in 1 mil	P. D. & Co.
Klotogen	Liquid, 1250 units (Almquist method) equivalent to 46,500 Dam units per mil. Capsules, 1000 units (Almquist method) equivalent to approx. 37,500 Dam units.	Abbott
Menaphthone	"Tabloid," 2 mg. per "tabloid." "Hypoloid" ampoules, 5 mg. in 1 mil.	B. W.
Prokayvit	Ampoules, 5 mg. menaphthone per mil. Tablets, 10 mg. acetomenaphthone per tablet. Solution, 10 mg. capsules in oil solution	B. D. H.
Synkavit	Tablets, 10 mg. (tetra-sodium salt of 2-methyl-1 : 4-naphthahydroquinone diphosphate), water-soluble vitamin K analogue. Ampoules, 10 mg.	Roche
Vitamin K	Capsules, 1/3 mg. methylnaphthaquinone. Ampoules, 5 mg. in 1 mil	Crookes Labs.
Vitamin K	Ampoules, 10 mg. menaphthone per mil. Tablets, 10 mg. acetomenaphthone	Paines & Byrne
	Vitamin P	
Vitamin P	Ampoules, 10 mg. hesperidin per 1 ml.	Crookes Labs.
Permidin	Tablets, 150 mg.	Glaxo
	Combinations	
Abecedin	Tablets, 4500 I.U. A, 50 I.U. B_1, B_2, equal to 2·5 gm. fresh brewer's yeast, 200 I.U. C, 600 I.U. D_3 per tablet. Emulsion, similar constituents per fl. drm. excluding B_2	Napp

Name of Preparation.	Description.	Makers.
Abidon	Capsules, 4500 I.U. A, 30 I.U. B_1 10 Sherman units B_2, 450 I.U. D per capsule	P. D. & Co.
Abidon with Vitamin C	Capsules 4500 I.U. A, 50 I.U. B_1, 20 Sherman units B_2, 10 mg. C per capsule, 450 I.U. D	P. D. & Co.
A B D Capsules	Capsules, 5000 I.U. A, 30 I.U. B_1, 10 Sherman units B_2, 500 I.U. D	Abbott
A B D Capsules	3000 I.U. A, 0·3 mg. B_1 per capsule. 40 Sherman-Bourquin units B_2, 200 I.U. D	A. & H.
A B D G	Capsules, 6600 I.U. A, 33 I.U. B_1, 0·02 mg. B_2 (Riboflavine), 1320 I.U. D per capsule	Squibb
Befortiss	0·3, 1·0, 3 mg. B_1 with other factors of B complex	Vitamins, Ltd.
Beta-Cevalin	Capsules, 167 I.U. B_1, 12·5 mg. C per capsule	Lilly
Crysto-Vibex with Vitamin C	Tablets, 0·5 mg. B_1, 12·5 mg. C per tablet	P. D. & Co.
Davitamon Five	Tablets, 1000 I.U. A, 50 I.U. B_1, 0·5 mg. nicotinic acid, 10 mg. C, 200 I.U. D per tablet	Organon
Halibol B Capsules	Capsules, 4500 I.U. A. (B_1 and B_2 equal to 5 grains dried yeast.) 900 I.U. D per capsule	A. & H.
Halibol Malt	8400 I.U. A, 1100 I.U. D per oz.	A. & H.
Haliborange	600 I.U. A, 150 I.U. D, 1 mg. C per gm.	A. & H.
Halimalt	Liquid, 4300 I.U. A, 420 I.U. D, 44 I.U. B_1 per dr.	Crookes Labs.
Haliver Malt with Viosterol	28,000 I.U. A, 50 I.U. B_1, 50 Sherman units B_2—(0·125 mg.) Riboflavine per fl. oz., 8000 I.U. D	Abbott
Halycitrol	Liquid, 2600 I.U. A, 315 I.U. D, 2 mg. C per dr.	Crookes Labs.
Homicebrin	3000 I.U. A, 83 I.U. B_1, 200 Sherman units B_2, 200 mg. C, 1000 I.U. D	Lilly
Medicaps	Capsules, 4500 I.U. A, 33 I.U. B_1, 25 mg. C, 1320 I.U. D, 22 microgm. B_2, vitamin G, the whole of the B_2 complex	Savory & Moore

Name of Preparation.	Description.	Makers.
Multivite	Pellets, 2500 I.U. A, 160 I.U. B_1, 12·5 mg. C, 250 I.U. D_2 per pellet	B. D. H.
Nestrovite	Tablets, 2500 I.U. A, 0·5 mg. B_1, 20 mg. C, 500 I.U. D per tablet. Emulsion, 2500 I.U. A, 0·25 mg. B_1, 15 mg. C, 500 I.U. D per teaspoonful	Roche Products
Penta Kaps	Capsules, 4500 I.U. A, 75 I.U. B_1, 10 mg. C, 600 I.U. D, 20 Sherman units B_2 per capsule	Abbott
Priovit	1 mg. B_1, 25 mg. C, 15 mg. nicotinamide	Bayer
Radiostoleum emulsion with vitamin C	1500 I.U. A, 300 I.U. D, 50 I.U. C per gm.	B. D. H.
Vimaltol	46 I.U. A, 2·7–2·9 I.U. B_1, 35 I.U. D per gm.	Wander
Vitamin Tonic "Glanules"	6200 I.U. A, 100 Sherman-Chase units B_1, 10 mg. C, 945 I.U. D, B_2 liver concentrate (1 : 125) 60 mg. per "glanule"	Armour
Vitamin Quota	Capsule, 4500 I.U. A, 100 I.U. B_1, 450 I.U. D, 100-γ B_2 per capsule	Crookes Labs.
	Miscellaneous Preparations	
Bemax	280 I.U. A, 320–420 I.U. B_1, 0·9 mg. B_2, 1·1 mg. P.P. factor, 0·45 mg. B_6, 8 mg. E, magnesium 99 mg., 330 mg. phosphorus, 2·7 mg. iron, 0·45 mg. copper per oz.	Vitamins, Ltd.
Cofron Capsules	Capsules, approx. 40 Sherman units B_2—(0·1 mg.), approx. 5 I.U. B_1 from liver per capsule with iron and copper	Abbott
Cofron Elixir	Approx. 35 I.U. B_1, approx. 180 Sherman units B_2 = 0·45 mg. Riboflavine from liver, per 3 tablespoonfuls with iron and copper	Abbott
Colact	Sweetened milk-cocoa with 65 I.U. D per oz.	Glaxo

Name of Preparation.	Description.	Makers.
Complevite . .	Tablets, Vitamin A 4000 I.U., B_1 0·6 mg., C 20 mg., D 300 I.U., calcium 160 mg., iron 68 mg., iodine, manganese, copper 3 parts per million	Vitamins, Ltd.
Decufer Tablets	Tablets, 20 mg. reduced iron, 0·2 mg. cupric carbonate, 0·2 mg. manganese chloride, 500 I.U. D (calciferol)	Organon
GlucoDin . .	9 I.U. D per gm.	Glaxo
Glucose-D T.B.	250 I.U. D per oz..	A. & H.
Glucose-D . .	250 I.U. D per oz..	Glaxo
Hebulon . .	Capsules, 25 I.U. B_1 and liver extract from 16 g. fresh liver contains in addition B_2 and B_6. Ferrous sulphate exsiccated 2 gr. per capsule	Squibb
Iberin . . .	22 I.U., B_1, 20 Sherman units B (B_2) with iron ammonium citrate and liver concentrate per capsule	Abbott
Irradex . . .	6600 I.U. A, 2200 I.U. D, 75 I.U. B_1. Iron and ammonium citrate 4 grs., manganese citrate, soluble ¼ gr. with malt extract, in each fl. oz.	P. D. & Co.
Ostermilk No. 1	200 I.U. D per reconstituted pint	Glaxo
Ostermilk No. 2	165 I.U. D per reconstituted pint	Glaxo
Ostomalt . .	220 I.U. A, 50 I.U. D with malt extract, calc. glycerophosph. and concentrated orange juice	Glaxo
Pregnavite . .	Tablets, Vitamin A 4000 I.U., B_1 0·6 mg., D 300 I.U., E 1 mg., nicotinamide 25 mg., calcium 160 mg., iron 68 mg., iodine, manganese, copper 3 parts per million	Vitamins, Ltd.
Radio-Malt . .	2000 I.U. A, 1000 I.U. D_2, extract of yeast equivalent to 0·1 oz. fresh yeast in each fl. oz.	B. D. H.
Viozin Ointment	500 I.U. D per gm.	Glaxo

The values for the different vitamins are expressed either in international (I.U.) units or those in common use and in terms of the actual vitamin if this is known. The weights of the vitamins are expressed either in milligrams (mg.) or in γ or microgramme (where γ is $\frac{1}{1000}$ part of a milligramme).

Vitamin A. One international unit (I.U.) = 0·6 γ of pure β-carotene.

Vitamin B. One I.U. = 3 γ and 333 I.U. = 1 mg.
Other vitamins of the B complex :

Riboflavine. There is no international unit and one Sherman unit = 2·0–2·5 γ of pure riboflavine.

Nicotinic acid (P.P.). The pure substance is known.

Vitamin B_6. There is no international unit and one rat unit = 5γ (*circa*). The pure substance is known.

Vitamin C. One I.U. = 0·05 mg. and 1 mg. of ascorbic acid = 20 units.

Vitamin D. One I.U. = 0·025 γ calciferol.

Vitamin E. (α-Tocopherol) One I.U. = 1 mg. of the standard substance (synthetic racemic α-tocopherol acetate).

Vitamin K. There is no international unit and the Dam units are given.

The following substances have some caloric value besides their vitamin content :

Bemax, which is prepared from the wheat embryo by removing all foreign material, contains protein 34 per cent., starch 38 per cent., soluble carbohydrate 8·5 per cent., fat 8·5 per cent., mineral salts 4·5 per cent., water 5 per cent., and fibre 1·5 per cent. One ounce contains 90 I.U. of vitamin A, 320–420 I.U. of vitamin B_1, some riboflavine, 0·85 milligramme, and other members of the vitamin B complex, nicotinic acid, filtrate factor, eluate factor. It also contains some vitamin E. The caloric value of one ounce is 116.

Bynotone contains sugar 49 per cent., protein 11 per cent., fat 6·2 per cent., and 360 I.U. of vitamin A, and 90 I.U. of vitamin D per gramme. The caloric value of one ounce is 86.

Glaxovo contains fat 14·5 per cent., protein (mainly first-class) 17·5 per cent., carbohydrate 59·9 per cent., mineral salt 4·0 per cent. One ounce of the dry powder contains 237 I.U. of vitamin D. The caloric value of one ounce is 138.

Miol contains emulsified olive oil 9·12 per cent., Lecithin 0·028 per cent., Iodine Resublimata 0·00224 per cent., malt-extract 90·5 per cent. One ounce contains 5000 I.U. of vitamin A and 900 I.U. of vitamin B. The caloric value of one ounce is 100.

Plasmona contains lipoid compounds 10 per cent., extract of liver

4 per cent., protein (mainly first-class) 35 per cent., carbohydrates 35 per cent., inorganic salts 5·7 per cent. It contains an unstated amount of vitamins A, B, D and E, a little liver-extract, together with a little iron, calcium, and magnesium. The caloric value of one ounce is about 80.

Virol is prepared from bone marrow, the yolk of eggs and malt-extract, flavoured with lemon-juice, and contains approximately water 22·4 per cent., fat 11·7 per cent., carbohydrate 56·3 per cent., protein 4·1 per cent., and ash 1·3 per cent. One ounce contains about 2200 I.U. of vitamin A, and 314 I.U. of vitamin D. The caloric value of one ounce is 105.

Such artificial preparations are of no use whatever in dietetics unless the makers print and guarantee their vitamin and mineral contents. There are many preparations on the market said to contain this, that and the other vitamin which are almost innocent of them.

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